CPSC Staff Statement on Motiv Report "Technical Feasibility and Cost Improvement Analysis of Safer Window Covering Technologies"[1]

February 2017

The report titled, "Technical Feasibility and Cost Improvement Analysis of Safer Window Covering Technologies," presents information on the cost of the safer window covering technologies and options to reduce that cost. The report also provides information on how the technological options affect the ease of use and aesthetic appeal of these technologies. The report addresses consumer preferences of a range of operating systems, analyzes cost and technical performance of selected window covering operating technologies, and addresses alternative design options and compares potential cost, safety, and performance improvements. Work was completed under contract CPSC-S-15-0072.

[1] This statement was prepared by the CPSC staff, and the attached report was produced by Motiv for CPSC staff. The statement and report have not been reviewed or approved by, and do not necessarily represent the views of, the Commission.

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Technical Feasibility and Cost Improvement Analysis of Safer Window Covering Technologies
CPSC-S-15-0072

Phase 5 Final Report
November 17, 2016

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Executive Summary

The purpose of this report is to provide information on the cost of the safer window covering technologies and options to reduce that cost. This document also provides information on how the technological options affect the ease of use and aesthetic appeal of these technologies. The report is divided into three sections.

Section 1 Background

Tasks
Objective of Section 1 is to gain an understanding of consumer preferences of a range of operating systems. To accomplish this Motiv conducted a variety of tasks to gain a working knowledge of the current landscape of window covering operating system technologies. Motiv investigated window covering safety, manufacturer, and CPSC websites. Team members shopped for window coverings online and at retail to understand the available range of operating mechanisms. Additionally, an online patent search was completed. With this information and with the guidance of the CPSC staff, Motiv generated a selection of window covering operating technologies to purchase, review, and test with focus group participants.

Results
Three focus group sessions were conducted. The results of the focus group indicate that the wand/slider technology was clearly preferred. Standard cordless and mechanized samples were contenders. Participants tended to prefer products that were easy to use and aesthetically simple. The data from the focus groups was used to identify which of the operating technologies merited further study in section 2 of this report.

Section 2 Engineering Discussion and Analysis of Available Technology

Tasks
The goal of section 2 is to analyze selected window covering operating technologies, identified in section 1, for cost and technical performance. For each sample the technology and mechanism used to perform tilt and raise/lower motion was identified. The component level cost of each technology was determined and the limitations of each technology (wear, size, weight, durability) captured.

Results
There was no observable correlation between high cost product and high focus group ratings. The cost of many products is concentrated in a few key components. Constant force springs for the cordless samples comprise approximately half of the total product cost. Control rods and high cosmetic elements (painted components) compromise major cost budgets within products. The cord lock solution is the

cheapest by far of any products tested.[1] It is widely adopted, but is deficient in perceived and actual safety ratings. It is suspected that this is purchased based solely on price, making it difficult for safer more expensive solutions to compete. In light of these results paths were identified for further study in section 3.

Section 3 Options Development Discussion

Tasks

This section focuses on generation of alternative design options and comparing potential cost, safety, and performance improvements. Section 2 identified two paths of focus. The first path integrates additional safety items into the baseline cord lock technology to maintain low cost but improve safety. The second path addresses specific concerns and cost challenges in the mid-range and high-end products to offer potential adoption away from the lowest priced solutions and those that do not eliminate exposed hazardous cords or loops.

Results

Seven different options were further selected from an array of initial ideas and vetted for viability, cost and potential safety improvement. Four potential solutions for cord-lock technologies are included that can improve safety but require up to a 30% cost increase in the baseline products. This cost delta can be significant in the lowest cost solutions available in the retail market. In higher cost (mean retail price) products, the increase in manufacturing cost has a much lower impact on overall price. Within the continuous loop cord window covering technologies, two solutions attempt safety improvement by reducing the exposed cord lengths but these do not meet the highest safety standards targeted by the CPSC staff. The loop cord solutions showed only small changes in overall cost of goods. The shorter cords do have an impact on ergonomic reach and may not be appropriate for all potential customers. Finally, a cordless mechanism was investigated as an alternative design to reduce the overall cost. This option potentially shows a cost reduction compared to the available cordless mechanisms but not significant to make the cordless solutions compete directly with cord lock products in the retail environment.

The window coverings market is a saturated market with extensive research and development and considerable existing intellectual property. All window coverings reviewed and dissected in the program to date have been commodity-designed products using appropriate high-volume design methods. There is no “low-hanging fruit” to reduce the cost of the baseline products. Path 1 solutions can add safety but will increase the cost of the products that are lowest priced and sold in highest numbers. Path 2 solutions revealed that it may be possible to slightly reduce the cost of more expensive and safer products, but this may not be significant enough improvement to drive purchase over lower cost and less safe products.
Safer products are already available in the market, but consumers don’t buy them due to higher cost. Products that do not eliminate the hazard of accessible cords and loops, specifically the cord lock, also provide the best fit with consumer’s use scenarios (can access from any height, reach around furniture, accommodate short/tall, and multiple sized windows).

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[1] Cord lock systems use a cord which is pulled down to raise a window covering, automatically locking the cord in place until the user pulls cord to the side in order to release and lower the window covering.

1 Background

1.1 Introduction

The staff of the Consumer Product Safety Commission (CPSC) is evaluating various existing and potential products such as cord retractors, cord shrouds, cranks, and manual and motorized cordless products to address strangulation hazards associated with corded window coverings. As part of this effort the CPSC staff has awarded a contract to The Motiv Design, llc (Motiv), CPSC-S-15-0072 Technical Feasibility and Cost Improvement Analysis of Safer Window Covering Technologies, to conduct technical feasibility and cost improvement analysis on the available safer technologies that address child strangulation on a wide variety of window covering types and sizes.

The purpose of the contract is to provide information on the cost of the safer technologies and options to reduce that cost, including information on how widely the technological options can be implemented in terms of window covering type, size, and weight. The report also provides information on how the technological options affect the ease of use and aesthetic appeal.

Motiv outlined and undertook a five-phase approach to achieve this goal. The phases are as follows:

Phase One Existing Product and Intellectual Property Landscape

Phase Two Product and Intellectual Property Evaluation

Phase Three Concept Cost Optimization and Reduction

Phase Four Research and Usability Testing

Phase Five Final Report

For technical aspects of this project Motiv engaged a sub-contractor, Acorn Product Development (Acorn). Acorn provides comprehensive product engineering services, and was engaged for their expertise in engineering analysis, materials cost analysis, manufacturing cost reduction, and product development.

Both parties were involved in all phases of this contract. Acorn provided technical expertise in phases 2 and 3 to conduct cost analysis and develop new concepts. Throughout this document, “Motiv” refers to the combined teams of Motiv and Acorn.

This report summarizes information from Phases 1 to 4 and is divided into three sections.

Section 1 of this document presents background information and reviews activities and results conducted in Phases 1 and 4. Phase 1 provides an overview of the window covering operating systems and identifies systems that should be further studied and used in the Phase 4 focus groups. The purpose of the Phase 4 focus groups was to collect information about consumer preferences for various window covering operating systems (also referred to as actuation mechanisms). The results of these phases guided the work in the remaining phases of the project.

Section 2 of this report presents results of the phase 2 technical evaluation of existing window covering technologies identified in phase 1 and studied in the focus groups. The purpose of phase 2 was to develop an understanding of how various operating system technologies work, analyze manufacturing costs, understand aspects of durability, and identify limitations. This technical information is the basis for developing new conceptual actuation mechanisms in phase 3 of the project. Section 3 of this document summarizes the mechanical concepts developed in phase 3 of this project. Phases 1,2 and 4 provided the foundation for the team to develop new conceptual operating mechanisms. The purpose of phase 3 was to create concepts that address ease of use and safety while optimizing and reducing overall manufacturing costs. In addition, section 3 also assesses each concept's intellectual property risks, limitations, durability, ease of use, and aesthetic appeal.

Another document (CPSC Technical Feasibility and Cost Improvement Analysis of Safe Window Covering Technologies Supporting Documentation) provides more detailed information for all phases, including: patent search, window covering safety websites, lists of products of interest for further study, product tear downs, product cost analysis, conceptual mechanisms, research facility setup designs & photos, and focus group analysis.

1.2 Phase One – Existing Product and Intellectual Property Landscape

1.2.1 Objective and Methodology

The goal of phase 1 was to immerse the investigators in the world of window covering mechanism safety. Motiv conducted preliminary market research to understand the products and mechanisms and how the industry and other organizations communicate aspects of window covering mechanism safety. Motiv investigated window covering offerings at various retailers, including big box retailers, home improvement centers, dealers, and online retailers. Additionally, the CPSC staff provided samples and called attention to additional products of interest.

Motiv identified and purchased 19 window covering actuation samples and selected of a subset of these products for use in the phase 4 focus groups.

The original 19 samples range in actuation technologies and price: five products used a corded operating system and 14 products used cordless operating systems. The corded operating systems were cord lock and continuous loop while the cordless operating systems were wand/slider, wand, manual lift, manual lift with button, and motorized. Appendix A lists all 19 products in the starting sample list.

Motiv, with input from CSPC staff, further refined the list of samples to eliminate duplicate actuation systems for products to be used in phase 4 Focus Groups. Where possible, samples were selected with similar window covering appearance in size (24 inches wide and 48 inches long), and shape to reduce variables for the phase four focus group evaluations. One sample of each operating mechanism technology was selected. Figures 2 through 13 show the final products used in focus groups.

In addition, Motiv designed and constructed a test fixture that would allow participants to evaluate the samples side by side (Figure 1). The products were installed and assigned random three digit numeric identifiers so that Motiv could easily identify the products throughout the following phases.

Figure 1. Focus Group Samples

1.3 Phase Four – Research and Usability Testing

1.3.1 Objective and Methodology

With the window covering mechanism samples selected for testing and test fixtures designed, Motiv and the CPSC staff began phase 4.

The objectives of phase 4 were to conduct focus group testing and to use the participant feedback to inform phases 2 and 3. The focus groups provided the CPSC with qualitative data regarding consumers' experiences with existing corded window covering products in the home. The feedback conveyed consumers' reactions to:

- The operation and usability of the 12 selected products
- The aesthetic appeal of the mechanical product controls
- The perceived safety of the product controls
- The overall product performance, appeal, and usefulness in their homes

The qualitative focus group study was conducted in the Boston area on January 28, 2016. There were a total of 30 participants divided into three groups of ten. All participants were homeowners that have at least three corded products in their homes. Participants understood the hazard associated with corded products and expressed a high level of concern about the hazards of hanging cords. Group A consisted of mothers between ages 25 and 49 with children between ages 5 to 8 living at home. Group B consisted of grandparents over age 61 with grandchildren between ages from 5 to 8 that visit their home once a month or more. Group B was evenly divided across gender, i.e., half the group was male and half the group was female. The final group, Group C consisted of fathers between ages 25 and 49 with children between ages 5 to 8 living at home.

During the focus group sessions, respondents stood in front of each product sample and were encouraged to provide written and oral comments in reference to the product's ease of use and or safety. Specifically, participants were asked to operate each sample, e.g., raise or lower the blind, and determine whether they would purchase the product for home use. In addition, participants provided a ranking associated with the following product characteristics:

- Ease and smoothness of operation;
- Feel of control (i.e., ability to grip and operate);
- Appearance of control mechanism;
- Perception of safety; and,
- Overall product performance and satisfaction.

Rating is based on a 5-point scale with rank of 1 indicating low acceptance and 5 indicating high acceptance.

1.3.2 Description of Technologies

Cord Lock (438)

The cord lock actuation technology is a gravity-based system actuated by a single pull cord. The pull cord is trapped between a v-shaped groove and a friction roller. With no user tension applied to the pull cord, the weight of the window covering draws the pull cord between the groove and roller, creating a locking wedge. To release, the user maneuvers the pull cord to one side of the v-groove, which releases the friction roller. The window covering is then able to move up and down.

Figure 2. Cord Lock (438)

Continuous Loop Cord with Tension Device (384)

The continuous loop cord actuation mechanism raises and lowers a window covering via cables connected to spool in head-rail. The user manipulates a continuous loop cord attached to a pulley mounted to the window frame, and another pulley mounted in head-rail. As the loop cord is pulled, it rotates the head-rail pulley and drives up the covering. Continuous loop cords can be beaded, or textured to create higher friction and locking between cord and pulley. The bottom loop cord pulley requires mounting to window frame or stationary surface or unit will be partially inoperable.

Figure 3. Continuous Loop Cord with Tension Device

Tethered Loop Cord (567)

The tethered loop cord actuation mechanism is very similar to a continuous loop cord in operation. The user pulls the loop cord to spin a pulley/cord combination in the head-rail to raise the covering. Mechanically it differs from the continuous loop cord as the tethered loop cord contains a head-rail pulley and lower pulley are physically linked on a single frame. This still creates a loop, but the loop is filled with the frame material. The lower pulley does not require an additional mount to wall or window, since pulleys are connected within the device.

Figure 4. Tethered Loop Cord (567)

Wand/Slider (242)

The wand/slider mechanism is mechanically similar to the tethered loop cord technology yet presents a different actuation experience to the user. The user operates a slider on a wand, which drives a continuous loop that winds and unwinds the spool in head-rail attached to cords on the window covering. The user pulls slider down to raise, pushes slider up to lower. The loop tether is created by an enclosed tube that wraps around the outside of the loop. The lower pulley is connected to the tube and holds the loop taught during operation. The slider is attached to the tube through slots inside that allow the slider to move up and, the slider being attached to one of the loop cord sides. This mechanism uses a gear increase between loop cord pulley and cord spool to raise/lower window coverings. With 2:1 gearing, thus the slider can move half the distance at 2x the force to operate the full shade travel distance. Since loop is enclosed, and lower pulley is mounted to tube, no attachment of the wand/slider to window frame is required.

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Figure 5. Wand/Slider (242)

Cordless (no button) (271)

Cordless actuation technologies are a balanced spring system. The coverings are attached via inner cords to a spool system in the head rail. A series of internal springs support the spools and balance the mass of the covering. The residual mass bias draws the spring mechanism together creating a locking friction force. When the user applies enough force to the lower rail to overcome the bias force of the springs, the friction lock is removed and the user can operate the window covering. Once the user force is removed, the friction lock is again engaged (due to residual force imbalance) and the window covering stays at the target height. The spring and locking friction is specific to each product width and window covering/shade materials and mass.

Figure 6. Cordless (no button) (271)

Cordless (button) (715)

This cordless technology variant uses a button to lock the operating height. The inner cords and associated spools are still almost counterbalanced by internal springs. To lock the motion, the operating spool is mechanically locked via a pawl/button actuator that the user can operate. In order to operate the product again, the user must press the button to release the pawl and allow the inner cord spool to rotate. The user is able to push/pull the shade to the target height. When the button is released, the pawl engages and locks the product height. The pawl only requires a small overall force due to the spring counter-balance. The spring balance in the button variants is less critical, since the pawl can resist a larger force range than the friction balance of the standard cordless (cordless (no button) 271) options.

Figure 7. Cordless (button) (715)

Cordless (with tilt wand) (467)

This cordless technology uses a spring system to raise and lower the window covering. A separate wand is used to tilt the horizontal slats.

Figure 8. Cordless (with tilt wand) (467)

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Motorized (186)

In this actuation technology is contains a motor, powered by internal batteries and actuated by a remote control device, and is connected to window covering with cord. Pressing one button will raise the covering and a separate one lowers it. As the motor spins, a small gearbox reduces its overall speed and spools cord onto a pulley. In order to lower the product, the motor spins in the opposite direction and cord is unwound from spool. The weight of window covering allows window covering to lower. In order to lock the window covering in a desired position, the motor must be turned off so the gearbox/pulley cannot be back-driven which keeps the window covering in place. These motorized technologies provide no manual over-ride option.

Figure 9. Motorized (186)

Ratchet with Pull Wand (354)

In this mechanism, the window covering body is connected via cords to a spool in head rail. The user pulls the wand, which winds the head rail spool in small increments and raises the window covering. Each pull of the wand is geared up to create a larger rotation of the window covering winding spool. This requires more user input force for each pull than the weight of the shade. After each small user pull, spool is latched in place and the wand retracts and returns to initial position. This process is repeated until the shade is at the desired height. In order to lower the product, the user pulls the wand to the left and this releases the lock so the shade can lower.

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Figure 10. Ratchet with Pull Wand (354)

Crank (179)

The Crank actuation technology is a direct drive system in which a large crank is attached to head-rail, driving a cord/spool mechanism that raises and lowers the window covering. There is a geared connection between crank and cord spool to create large motions of shade travel with small crank inputs. The spool is locked via friction in the mechanism to maintain shade height. The crank is permanently connected to product but could be removable. Additionally, the crank can collapse from z-bend profile to a straight pole (our example) to minimize the bulk and visual appearance of the product.

Figure 11. Crank (179)

Push Pull Wand (230)

The push pull wand actuation mechanism is a direct acting system. Vertical slats are linked to slides across the head-rail. Vertical slats are also tethered to each other with small links/chain/cords. The actuation wand is attached to last ‘link’ in coverings. User slides the wand, this pulls first slat link, now first link pulls second link, etc. When user slides actuator wand in other direction, links compress and links now push against each other collapsing into a minimal stack.

Figure 12. Push/Pull Wand (239)

Twist Wand (317)

The Twist Wand is also a purely mechanical (direct drive) system. The user rotates wand connected via linkage to spool which, when turned clockwise, rolls the shade up with counter clockwise lowering the shade. There is no internal braking; the wand must be locked (held from rotating) to maintain shade position. A clamp/bracket was used in the sample product to hold actuator wand to window trim. Without this clamp the window covering will not stay in the desired position.

Figure 13. Twist Wand (817)

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1.3.2 Focus Group Summary of Results

An average of 10 horizontal corded window coverings are installed and used in the respondents' households, with a range of 3-27 units per home. Over half of the participants reported they operate (i.e., open and close their window covering) at least once a day.

There was a generally low perceived safety rating for the window coverings in their homes. On average, participants rated their products as 2.6 on a 5 point scale, with 5 indicating an extremely high degree of satisfaction and 1 indicating an extremely low degree of satisfaction.

Overall, participants provided a rating for satisfaction and performance with their products at home averaged 3.1. This indicates consumers feel lukewarm about their current window covering solutions and that there is room for improvement in the window covering product space.

Almost three-fourths of all 30 respondents in the study (73%) said that their window coverings were "easy to reach, access, and operate." The remaining 27% indicated that their window coverings were not easy to each, access, or operate because furniture blocked access to their products.

Participants indicated that Wand/Slider (242) was their first choice- ranking the highest in all three "Safety," "Overall Performance," and "Would Work Well in My Home" categories. Wand/Slider (242) was the "Clear Cut Winner" as it had the highest rating on "Safety" and "Overall Performance" and "Would Work Well in My Home".

Products ranked 2 through 8 can be considered "Contenders" because their average ranking for perceived safety and overall performance were above rank 3 and over half the participants indicated they would purchase or use the product in their home. Products ranked 9 to 12 can be considered "Losers" because their average rankings for all three categories were below rank of 3.

The table below presents the overall ranking for products used in the focus groups.

Table 1 Product Ranking by Technology

Rank	Identifier	Technology
1	242	Wand / Slider
2	467	Cordless (with tilt wand)
3	271	Cordless (no button)
4	715	Cordless (button)
5	186	Motorized

6	230	Push / Pull Wand (Referred to as Vertical Blinds in Phase 4 report)
7	354	Ratchet with Pull Wand
8	384	Continuous Loop Cord With Tension Device
9	567	Tethered Loop Cord
10	179	Crank
11	317	Twist Wand (Referred to as Cordless Roman Shade)
12	438	Cord Lock

1.3.3 Ease Of Use

In phase 4, participants in the focus group sessions used a five point rating scale to indicate their degree of satisfaction with product characteristics (see figure 96, appendix). The members participated in a group discussion about the overall performance of raising, lowering, tilting, and adjusting mechanisms for each product. The ratings and observations provided qualitative data for the ease of use of each product.

During the focus group sessions Motiv was able to observe participant interactions with the technologies. The team went on to compare observed mechanism issues and how the focus group members proceeded to rate and discuss the various samples. While this data is not statistically significant, it is valuable to further explain window covering mechanism preference.

Table 2 Ease of Use Ranking Averages

Rank	Sample Number	Product Name	Ease Of Use Average
1	242	Wand/Slider	4.47
2	467	Cordless (with tilt wand)	4.27
3	271	Cordless (no button)	4.2
4	715	Cordless (button)	4.1
5	186	Motorized	4.05
6	230	Push/Pull Wand	3.64
7	384	Continuous Loop Cord with Tension Device	3.56
8	354	Ratchet with Pull Wand	3.3
9	438	Cord Lock	3.33
10	179	Crank	2.77
11	317	Twist Wand	2.1
12	567	Tethered Loop Cord	1.95

1.3.3.1 Difficult To Use Technologies

Operating mechanisms were deemed too difficult to use if they required repetitive or time consuming motions, were difficult to grasp and manipulate, or produced unexpected user behaviors.

The Tethered Loop Cord (567) was consistently rated 2 and below across all categories. None of users imagined that it would work well in their home leading to the conclusion that it's the most difficult to use of all the tested technologies. The fixed wand made the loop tight and difficult to access. Additionally, some first time users would pivot the entire wand instead of pulling the loop cord, highlighting that a technology such as this may require trial and error experimentation before proper use.

The Twist Wand (317) is the second lowest rated on the four scales. This technology required the use of a tension clip to hold the wand when the window covering was raised. After raised, if the user failed to lock the wand into the retention clip, the wand would spin freely and the shade would lower. This came as an unexpected surprise to new users and, as the ratings revealed, was not preferred.

The Crank (179) sample is the third lowest rated on the ease of use scales. Despite that the users found the crank easy to turn, it required a great number of rotations to raise and lower the window covering. The time it took to spin the crank enough times to move the covering was perceived to be overly long and the rotating of the crank overly repetitive. Participants also commented that while this mechanism was easy to turn and therefor acceptable to use, having multiple window coverings with this mechanism in a house would require a lot more time to raise and lower all coverings than other technologies. The repetitive motion, length of time, and thought of performing this procedure on multiple window coverings was not preferred.

The Cord Lock (438) is also considered difficult to use to focus group participants. Participants discussed potential tangling and uneven raising and lowering of window coverings. This perception could also be because while it was not particularly difficult or easy to operate, the known safety issues with cord lock technologies influenced users' opinions.

1.3.3.2 Moderately Easy To Use Technologies

Some technologies that were deemed relatively easy to actuate by focus group participants still had aspects that detracted from their overall ease of use. These aspects did not negatively influence participant's opinions to the same level the samples discussed in 2.6.1 but still presented barriers to overall user acceptance. These aspects include comfort, finicky actuation, and large range of motion.

Users were able to raise and lower the Regular Loop Cord (384) with relative ease. While is it fairly easy to raise and lower the window covering, the users rated tilting and adjusting the covering strictly average, in the middle. Initially Motiv thought the beaded cord on this sample would provide additional grip, but instead this was perceived as uncomfortable to grasp and pull. Additionally the bottom anchor/tensioner, which is necessary for safety, made the loop tight and difficult to access. The off-putting texture of the beaded cord and the tautness of the loop lead participants to decide that this mechanism was not comfortable to use.

Participants had some initial problems operating the Ratchet with Pull Wand (354), specifically when attempting to lower the window covering. To do so, users had to pull the operating wand at an angle. The string connecting the wand to the head rail mechanism would then press against a mechanism unlocking the covering and allowing it to lower. On the first attempt users were not always able to actuate this hidden mechanism, after additional attempts most users were able to understand how to properly work this technology. The initial failed attempts at lowering presented a finicky operating experience to the users.

Participants found the Push/Pull Wand (230) to be slightly above the median for ease of use. Having to walk across the window left to right, right to left to open and close the covering was not preferred. This aspect worsens with wider window coverings. Competing technologies require less arm or full body motion to actuate.

1.3.3.3 Easy To Use Technologies

Technologies that presented simple, minimal controls were the easiest to use for focus group participants. Upon first use people were able to intuit how to operate the mechanisms and found them to be straightforward. Unlike the product samples in 2.6.2, any aspect that was initially slightly difficult or confusing was easily overcome during operation and forgiven when discussing the samples.

1.3.3.1.1 Motorized

The Motorized (186) sample was easy for focus group members to operate. Some participants were confused during first attempts at operation due to the remote being switched to a different frequency channel. Once a user was shown how to correct this they had no trouble operating the mechanism. Users commented that this sample, with it's wireless remote, would increase the ease of use for raising and lowering window coverings in hard to reach windows. Participants also commented that dead batteries or misplacing the remote would make it impossible to adjust the window covering. This was a concern for most users.

1.3.3.1.2 Cordless Samples

Three cordless samples were tested in the focus group sessions. All were deemed easy to use. With all cordless samples, some participants noted that it would difficult or impossible to use this mechanism in hard to reach and very tall windows. This is because a user needs to lift the bottom rail to the desired height and therefore it can only be opened as far as a user can reach. While this did not seem to impact users ratings on the ease of operation for these samples, it is clear that this is a limitation of this technology.

The Cordless With Button (715) was found easy to use in the focus groups. Participants easily located the handle on the bottom rail and the actuation button located at its center. In this sample it is necessary to press and hold a button to get

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the covering to raise, once pressed the covering will rise with no effort from the user. This perceived effortless actuation was preferred. While the button does not have to be pressed and held, the user has to pull with enough force to overcome the internal mechanism. While not difficult, this is a may be why the other cordless samples were found slightly easier to use.

The Cordless (271) sample was also found easy to actuate by participants. Raising and lowering the window covering was considered easy to accomplish. Tilt adjust occurs automatically when a user starts to raise or lower the window covering; some subjects found this initially confusing but shared a belief that if this sample were in their home they would grow accustomed to it over time and it would become easier to use. They would “figure it out,” and “get the hang of it”.

The Cordless With Tilt Wand (467) was easy to use by most participants. Because tilt and raise/lower are separate actuation mechanisms, this sample seemed slightly easier to use than sample cordless (271) where tilt/raise/lower are combined into a one activator.

1.3.3.1.3 Wand Slider

Observations revealed that users had very little difficulty operating Wand/Slider (242). In the individual ratings and group discussion it was evident that this sample is extremely easy for consumers to use and understand. The obvious slider and familiarity of turning the wand for tilt adjust provides the user with everything they need to operate this mechanism successfully.

1.3.3.1.4 Ease of Use Final Thoughts

Overall, consumers prefer mechanisms that present a simple appearance and experience. Users are willing to accept unfamiliar technologies provided initial use quickly reveals how to correctly operate the mechanism. This experience gives users the sense that the mechanism will be easy to learn and use. Comfortable handles, cords, and any other touch points can enhance the ease of operation.

1.3.4 Aesthetic Appeal

In phase 4, participants in the focus group sessions used a five point rating scale to indicate their degree of satisfaction with product characteristics. One of these characteristics, appearance of controls, allowed users to rate the aesthetic appeal of each sample. The members participated in a group discussion about the samples during which they had the opportunity to share their opinion on the appearance of the various samples. The ratings and observations provided qualitative data for the aesthetic appeal of the product samples. This section incorporates this data combined with Motiv's expertise in design for household products to provide observations and conclusions regarding the aesthetic appeal of the tested samples. Summaries of samples are in order of least to most appealing and are divided into least, moderate, and most aesthetically appealing.

Table 3 Aesthetic Appearance Rating

Rank	Sample Number	Product Name	Appearance of Controls
1	186	Motorized	4.5
2	715	Cordless (button)	4.1
3	242	Wand/Slider	3.9
4	271	Cordless (no button)	3.9
5	467	Cordless (with tilt wand)	3.6
6	230	Push/Pull Wand	3.5
7	384	Continuous Loop Cord with Tension Device	3.2
8	354	Ratchet with Pull Wand	3.2
9	438	Cord Lock	2.7
10	179	Crank	2.5
11	317	Twist Wand	2.3
12	567	Tethered Loop Cord	2.1

1.3.4.1 Least Aesthetically Appealing Samples

Some of the samples tested in the focus groups were not found aesthetically pleasing. Participants concluded that these samples would be an eyesore if installed in their homes. It should be noted that the last sample in this section is the Cord Lock (438). Though focus group members do not find the Cord Lock appealing, they all currently have at least one of this type of control mechanism in their homes.

The Tethered Loop Cord (567) has the least preferred overall appearance of the samples. Composed of multiple pieces, it looks technical and complex which detracts from its over all aesthetics. Users commented that it looked functional but not pleasing. They expressed concern about the mechanism standing out and being an eyesore, which would be worsened when installed in a setting requiring multiple window coverings.

The Twist Wand's (317) appearance is also not preferred by participants. Users described the mechanism as looking inexpensive, cheap, and flimsy. The wand has a feature on it that allows it to mate to a retention clip fastened to the window frame. This feature reduces the cleanliness and simplicity of the wand. The retention clip consists of folded metal adding to the cheap and unfinished appearance of this operating mechanism. Due to this mechanism coming with coverings in preset widths, depending on the size of the window frame, when the wand is clipped into place it may be bent at a unattractive angle.

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The Crank (179) did not appeal to most focus group members. They expressed that this sample looked too functional and industrial in a negative, undesirable way. This industrial look is due to the metal material of the crank, the articulated joints and visual pivot points, and the fluted grip detail of handle. Like the Tethered Loop Cord (567) the crank's poor appearance would be worsened when installed in a multi-window covering setting.

The Cord Lock (438) was also not preferred by participants. While participants are very familiar with the technology and have at least one product in their homes, they do not like its aesthetics. More than one person commented that the standard tilt wand appears cheap. The long double cord wrapped around a cleat on the window frame adds undesirable visual noise to the window covering.

1.3.4.2 Moderate Aesthetically Appealing Samples

This section discusses the samples that were found to be acceptable in appearance. While not the favorites of the samples tested, participants did not find the look of these samples objectionable like those in section 1.3.4.1.

The overall appearance of the Ratchet With Pull Wand (354) sample was acceptable to users. Users reacted positively to its two wand controls, which was said to look cleaner than the cord and cleat of the Cord Lock sample.

The Cord Loop (384) was also found acceptable to users. Since the Cord Loop is a continuous uninterrupted loop, it lacks visually noisy parts such as tassels and knots that other corded operating systems, such as Cord Lock (438), posses. Additionally the loop is held tightly against the window frame helping to visual minimize its appearance. These aspects make this sample more appealing than those previously listed.

The Push Pull Wand (230) operating system was sufficiently aesthetically pleasing to focus group participants. The appearance of the control consists of one simple wand that ends with an identifiable handle. This sample may have suffered from negative bias due to the type of window covering it controls, vertical blinds, which are seen as outdated and unattractive. This potential bias is mentioned because a mechanism with an almost similar appearance, wand/slider (242) was more preferred.

1.3.4.3 Most Aesthetically Appealing Samples

Focus group participants found the samples in this section to be the most aesthetically pleasing. All of the cordless operating system samples are in this section.

Participants found Cordless (with Tilt Wand) (467) aesthetically appealing. It only has a wand for tilt/light adjustments. The window covering is raised and lowered by moving the bottom rail, so no additional control mechanism is visible. This reduced visual appearance is perceived as simpler than other samples and deemed appealing.

The Cordless (271) was found more appealing than the previous Cordless (467) sample. Unlike (467) this control mechanism does not have a separate wand to control tilt/light adjustment and as a result has a very simple overall appearance. The only part noticeable to the user is a plastic part on the bottom rail that provides a cue as to where to grasp the covering in order to raise and lower it.

The Wand/Slider (242) was also found to be aesthetically pleasing to focus group subjects. The wand provides all controls for the operating mechanism, twist for tilt/light adjustment and a slider for raising and lowering. The slider is an appropriate length and shape to clearly let the user know it is a point actuation. While the slider is obviously a separate part, it is the same color as the rest of the wand. This helps minimize its prominence and maintain a simple appearance for the overall control mechanism.

The Cordless (button) (715) mechanism, like the Cordless (271) sample, only has one visible actuation area and as a result has a very simple overall appearance. Users found the clean and minimal handle with a central button appealing. This handle is shaped in a way that makes it clear not only where to grasp but also how to grasp it. Motiv speculates that because the handle on this sample is more obvious than the cordless (271) sample contributes to it being more preferred.

The Motorized (186) sample was found to be the most aesthetically appealing operating system. No control is visible on the window covering. All controls are available on a separate cordless electronic remote. This technology gives users the option to put the controls wherever they want in their home. This gives them the option to have the controls suit their personal aesthetic preferences; they can hide the remote or make it visible as they see fit.

1.3.4.4 Aesthetic Appeal Conclusions

Participants see window coverings as predominantly functional devices and see their overall appearance as functional as well. The more these functional controls are reduced or less visible the better. Simpler appearing controls with reduced details that eliminate multiple parts, joints, knots, and other observable details are preferred. Visible controls that hang naturally and straight are preferred to any that noticeably bend, stick out, or are wrapped/tied up. Minimalist handles and indications of where to grasp a control mechanism can improve aesthetic appeal. Additionally, people have concern about what a control system will look like when applied to multiple windows.

1.4 Conclusion

Based on the results from the focus groups and with guidance from the CPSC staff, Motiv selected ten of the twelve tested samples to further examine in section two. It was decided to eliminate the Twist Wand (317) and the Crank (179) mechanisms because of their poor overall ratings by the focus group participants.

Although the Cord Lock (438) was also poorly received in the focus groups, all participants owned at least one window covering with this type of actuation mechanism. In terms of actual and perceived safety the Cord Lock rates the lowest. Additionally, the Cord Lock solution was the least costly of all the acquired samples. For these reasons this sample remained for further study in Section 2.

Based on strong user adoption of the cord lock products, an additional device, BlindWinder, was included for study in Section 2. This is an aftermarket retrofit device that is used to improve the safety of cord lock products. While it could not be included in the phase 4 focus groups because it was not an actuation technology in itself, it was deemed to have potentially valuable technology that could influence improvements and cost reductions in section 3.

2 Engineering Discussion and Analysis of Available Technology

2.1 Introduction

This section summarizes the technical analysis of the available window covering actuation technologies. This evaluation is focused on the examination of samples used in the phase 4 focus groups.[2] Each technology is evaluated for potential wear and failure points to understand its durability and limitations. Additionally, based on results of the focus groups and Motiv's expertise in developing household products, the technologies' ease of use and aesthetics are summarized.

2.3 Manufacturing Cost and Product Analysis

The total manufacturing cost (or total component cost) is the sum of each estimated cost to produce each part prior to assembly. This does not include assembly labor, test, packaging, or retail mark-up.

The total component cost of many products is concentrated in a few key elements. For example, constant force springs for the cordless solution comprise one-half of the total estimated component cost. Control wands and high cosmetic elements (e.g., painted components) also account for a high percentage of the total component cost of the products.

The motorized system has the highest part cost (as expected)- it takes far more parts to create, keeping in mind the different modules: the remote, the motor assembly, and the battery assembly.

[2] In addition to the samples evaluated by the focus group participants, Motiv and CPSC staff added a retrofit BlindWinder technology. The BlindWinder is a rectilinear plastic housing with internal spool mechanism for attachment of standard pull cord. The spool is nominally locked in place with a ratchet and pawl mechanism. It contains a small, side-actuated button to release pawl and allow the spool to rotate. A constant force spring applies torque on the internal spool and can retract free pull cord into the unit. To operate, the user pulls on the rectilinear package as a handle and mimics the standard cord lock operation (pull down to raise mechanism, pull left to release and allow mechanism to lower.) To return the BlindWinder to the safe position, the user must actuate the side button and guide the additional cord back into the unit and allow the unit to self-retract to the top of the window head-rail. The user must maintain contact pressure with the side button during the full retraction.

Figure 14 includes three cordless solutions (integrated tilt, the wand tilt, and no tilt) which are all similar in cost.

The Cord Lock system has the lowest overall cost of all 10 products; the manufacturing cost of which is significantly lower than all other systems. This due to the use of low quality, all plastic parts in addition to keeping the part number low overall. As expected, the simple mechanisms, 438 Cord Lock, have a fairly even distribution of part costs. No single part is driving the overall cost value (see Figure 15).

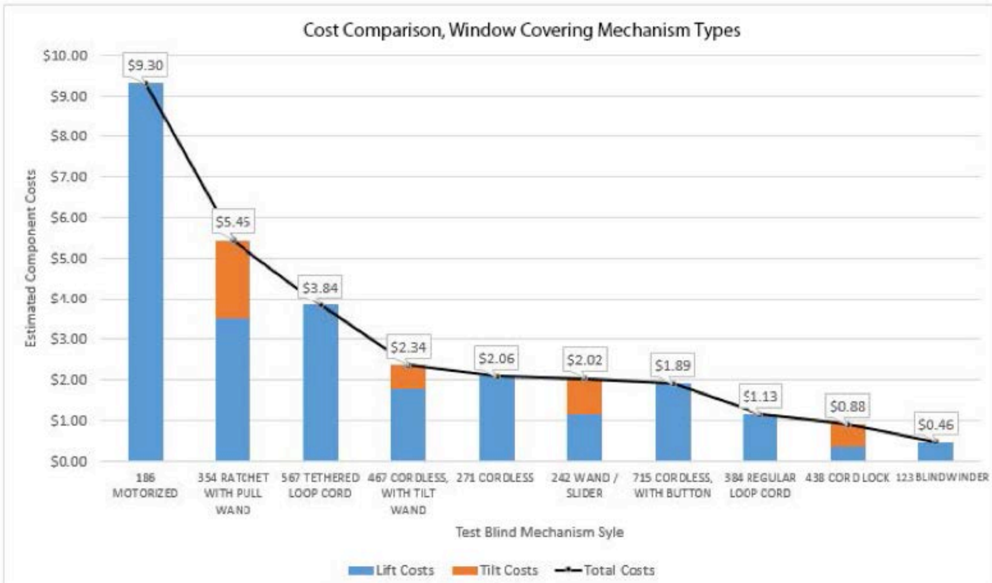

Figure 14. Cost Comparison, Window Covering Mechanism Types

The motorized system has the highest part cost (as expected)- it takes far more parts to create, keeping in mind the different modules: the remote, the motor assembly, and the battery assembly.

The manufacturing cost of the baseline products is often concentrated in a few key elements. In the cordless products, the constant force springs are a major contributor to the cost. Control rods and high cosmetic elements (e.g., painted components) also comprise major cost budgets within products. To demonstrate the impacts of singular components on the overall manufacturing costs, the estimated bill of materials is displayed in a Pareto chart format as shown in the following graphs.

As expected, the simple mechanisms, 438 Cord Lock, have a fairly even distribution of part costs. No single part is driving the overall cost value (see Figure 15).

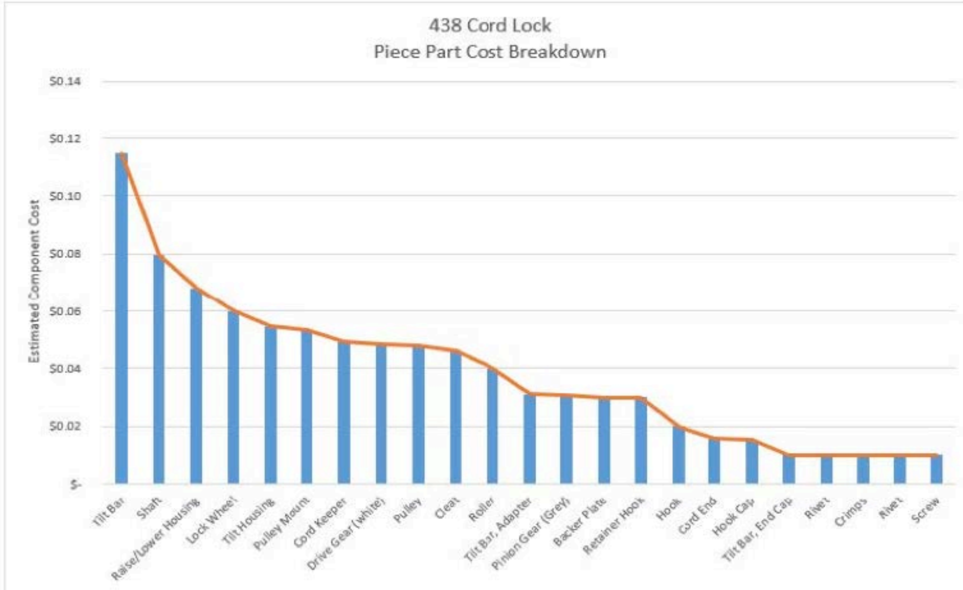

Figure 15. Cord Lock (438), Piece Part Cost Breakdown

In all of the cordless solutions studied, including Cordless (271), the constant force springs used to balance the weight of the window covering represent approximately half of the total product costs, as these the force springs are more expensive to manufacture than simple plastic parts (See Figure 16).

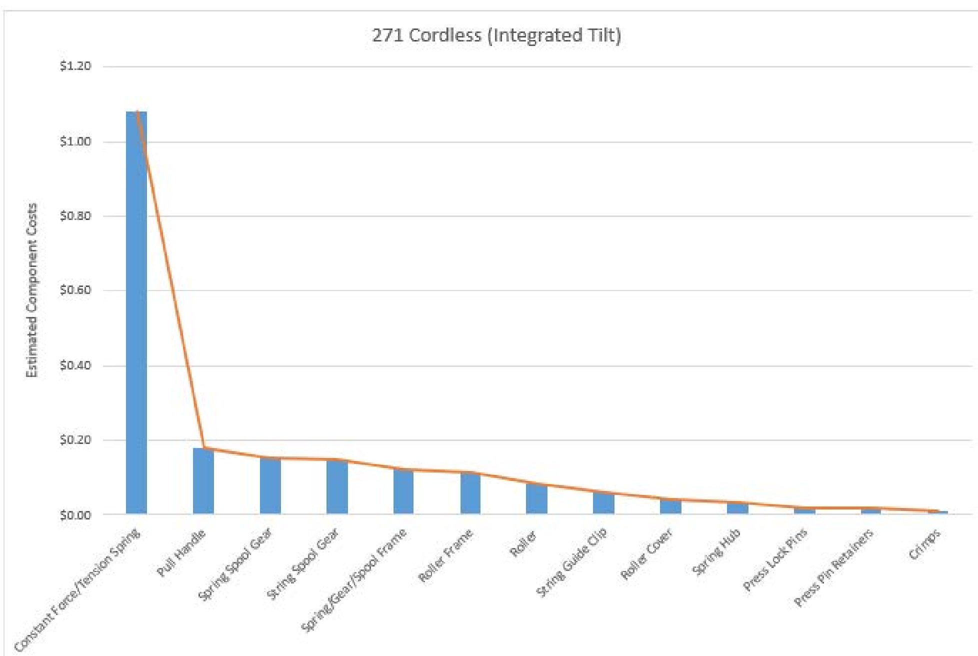

Figure 16. Cordless (271), (Integrated Tilt), Piece Part Cost Breakdown

Even in high complexity solutions, there are typically a few components that drive the overall costs. The designs of Wand / Slider (242), and Ratchet with Pull Wand (354) are executed using parts more complicated to manufacture, like higher cost extrusions (i.e., wands) and torsion springs, which play a part in these cost breakdowns.

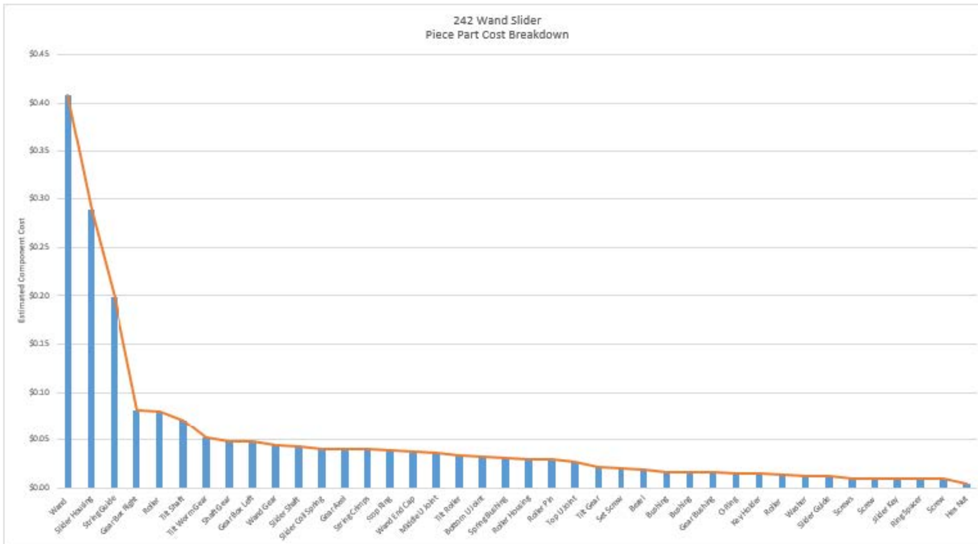

Figure 17. Wand Slider (242), Piece Part Cost Breakdown

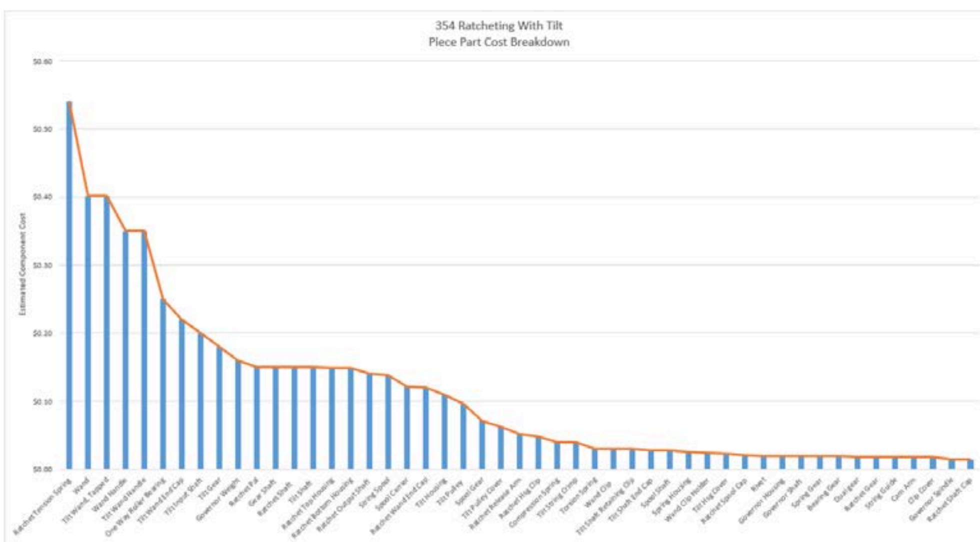

Figure 17 Ratcheting With Tilt (354), Piece Part Cost Breakdown

In general, the window covering mechanism components are optimized for high-volume, low-margin consumer products. There is limited opportunity for direct cost reduction in the components themselves.

There's some correlation between number of parts in the assembly and cost. The simpler mechanisms with fewer components usually have a lower overall cost. Figure 18 shows the number of parts in the lift mechanism versus the overall product costs. For those products that did not have a tilt function, only lift mechanism is shown.

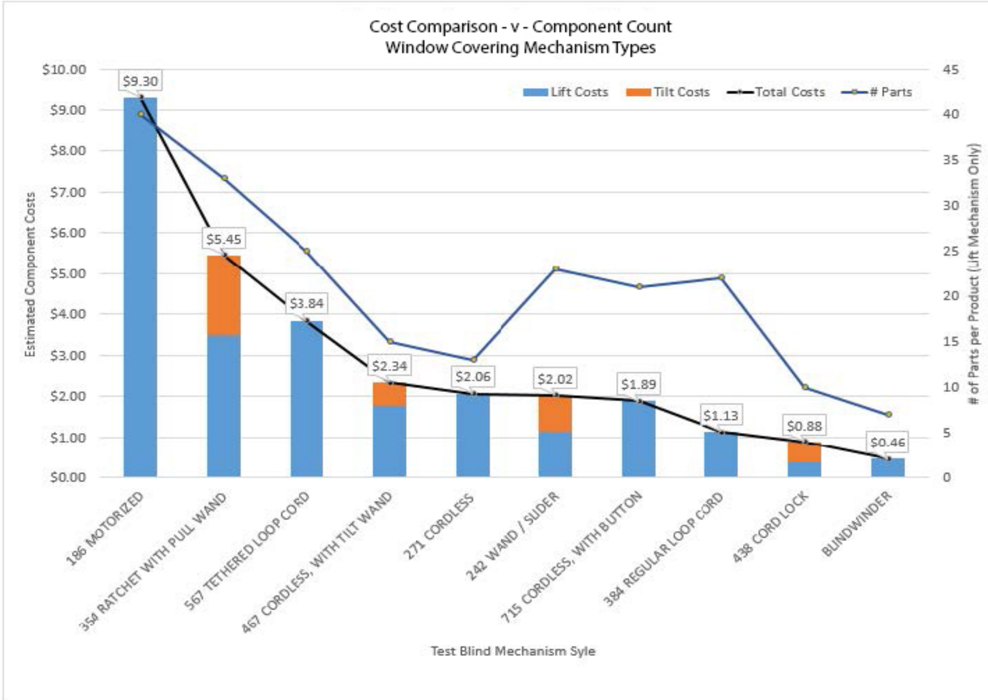

Figure 18. Cost Comparison -v- Component Count, Window Covering Mechanisms

2.4 Durability

Motiv and Acorn examined the actuation technologies independently from the focus groups. Mechanisms were broken down to analyze manufacturing processes and observations were made, primarily that investing in higher quality parts potentially reduces wear.

Wear and damage on the Cord Lock (438) cord over time would be expected. With use, the repetition of the roller digging into the nylon cord, overtime, will compromise the cords structural integrity. The end point of the operating cord terminates with a simple knot and has the potential to fail after overuse or plastic damage by UV exposure. Depending on where the cord is pulled, the cord joiner can break. The cord joiner, which works with a friction snap to hold the cords together, will not assemble after repeated separations. The heat-staked tilt wand adapter is prone to wear, and will result in reduced accuracy/feedback to the user. The loop and hook connection on the wand universal joint is not robust. It allows significant play and the user is required to over-twist to achieve the set-point. The tilt wand control uses plastic gears, which have significant play and can contribute giving the user an impression of low quality. However, it does not seem possible to over twist the wand and damage these gears.

Operating the Cord Loop (567) requires a relatively large amount of pull force on the cord, adding wear and friction on internal components. There is a torsion spring in winding shaft that cushions any hard stop position of window covering, but the amount of force applied to beaded cord can still cause the cord to break after time.

The window covering product Cord Loop with Integrated Tilt (384) uses a continuous loop operating cord. In order to raise or lower the product, the user must pull with a relatively large amout of force. The plastic sprocket mechanism and beaded string present a wear risk. It was noticed that a setscrew was loose on shaft stop collar during tear down, which could lead to possible failure if shaft moves out of engagement with clutch mechanism.

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The Wand/Slider (242) operates by a slider that is tied to pulley mechanism inside wand by small metal strip that rides inside groove along wand length. After use by the focus groups the product appeared to already have large amount of wear, as well as scratching of parts that have contact as slider moves up and down the wand. The gears inside tilt mechanism appeared susceptible to wear. Its teeth were already deformed and damaged before tear down.

Users of the Cordless with Button (715) technology are able to override the position lock and pull shade down without pressing button, which puts wear on the teeth of the lock wheel.

The weak area identified in the Cordless with Tilt Wand (467) technology is the plastic screw held stationary by end cap that moves to wind up the spool back and forth so string winds around in one layer. Use of constant force spring requires no button to raise or lower. Over time the plastic gears could wear inside both the raise and lower mechanism and tilt mechanism.

The Cordless with Integrated Tilt Mechanism (271) technology has large, robust gears that reduce the likelihood of wear and tear. Gears are protected in complete housing so the components will not be as exposed to dust or debris.

The Motorized (186) system is comprised of batteries, a battery holder, a motor, and remote control. The batteries will need replacing over time, the frequency of which depends on usage. Also requires significant number of batteries, 8 AA's. Battery tube must also be hidden within window frame and held by supplied tube clip holders. Motor MTBF (mean time between failures) is not known. Radio receiver is enclosed inside motor housing. Remote control stopped working on teardown sample.

The ratchet mechanism in the Ratcheting with Pull Wand (354) technology is fully enclosed in its own plastic housing. Components such as gears, springs, and toothed wheels, all appear to be high quality. The tilt mechanism uses all metal gears, making the product durable and less likely to wear, and the system is easy to operate.

The Retrofit BlindWinder (123) contains fragile, low quality components. So much so that a tongue holding string easily broke on the sample. Similarly, the housing is relatively thin, uses no mechanical fasteners, and easily came apart. This is likely a result of low-cost approach.

2.5 Performance Limitations and Analysis

In the detailed tear down of the samples Motiv identified limitations in each technology. These safety concerns are present in all cord operated samples.

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There is no mechanical advantage in the Cord Lock (438) lift mechanism. The amount of force the user needs to lift the covering is dictated by the weight of the window covering in addition to friction created by the system, which can be problematic as size of the covering increases. The cord must be long enough that the user can reach the reach the pull cord at the closed position of the window covering. This creates a very long cord at the open position of the window covering. This cord is either wrapped on the wall or looped over the head rail, which can lead to entanglement or knots or left dangling. The tilt mechanism is limited by the human wrist rotation limit; approximately 150 degrees. Gearing and pulley size must allow a full adjustment range within this range of human motion. With this technology there are some safety concerns. The cord creates a potential loop/strangulation risk when affixed to the wall, which cannot be mitigated by the break-away cord joiner.

The Cord Loop (567) cord wand is “bulky” and somewhat “awkward” to operate. There is limited space to insert fingers within the protected loop and larger/wider window coverings will require more force to move while the finger grasp dimensions remain constant. There is no stop position at the raised position and the cord continuously rolls around the main spool, making a jam in the raised position a possibility. There are limited safety concerns as there is very little loop formed.

The force required when raising the Cord Loop with Integrated Tilt (384) increases with the size of the shade. Limited to a left side cord position, there is no method to control uneven lower end of the window covering. The product appears to use gravity to self level, but it did not seem to easily level if it became uneven during any point of operation. Previous statements are affected by how string is taken up on spools. The pull cord is a safety concern, but risk is somewhat reduced with the lower end of the cord loop held to the window frame via tension device.

The Wand/Slider (242) takes too many turns of the user’s wrist to cover the tilting range, making opening and closing slats very tedious. Increased width of the overall assembly (weight) will make operation of the slider more difficult for the user. There is limited mechanical advantage to this technology. The operation is limited in stroke, and shorter operators may not be able to actuate the device across the full range. Reduced stroke (within operators reach) will require more force to operate the mechanism. There are no apparent safety concerns.

The Cordless with Button (715) window covering takes a significant amount of pull force to lower due to a tension spring. However, it makes it easier to raise the window covering. The string leveling adjustment screw features are a nice touch, and help trim the overall window covering to be level in the home. There are no apparent safety concerns.

The lower end of the Cordless with Tilt Wand (467) window covering has no leveling adjustment. Increasing force (size/cost of spring) may be needed to raise a wide window covering. The same common reach concerns apply here as they do with all cordless options. There are no apparent safety concerns.

Adjusting the tilt of the Cordless with Integrated Tilt Mecanism (271) could be challenging due to a small reversing motion required. Focus group feedback disagreed with this though, and no users reported difficulty. There are no apparent safety concerns.

The Motorized (186) system runs on batteries, which need replacing over time depending on usage. 8 AA batteries are required, which is a significant number per unit. The Battery tube must also be hidden within the window frame and held by supplied tube clip holders. There are no apparent safety concerns.

To tilt the slats on the Ratcheting with Pull Wand system (354) it takes too many rotations of the wrist (12+). Rearranging gearing system could minimize wrist rotations.
Pull strength/requirement to lift wider window covering is a concern. Current size (24 inches) takes considerable force to operate. Both wands, tilt and raise, do not present any apparent safety concern.

The user is instructed to pull on Retrofit BlindWinder cord to raise covering. However, when this device is in place the user is inclined to pull on mechanism housing, which could easily lead to failure. There are no apparent safety concerns.

2.6 Conclusion

The Cord Lock solution is significantly less expensive than any other products tested. It is widely adopted, and is deficient in perceived and actual safety ratings. Motiv believes it is difficult for safer, more expensive solutions to compete because cord lock purchases appear based solely on price. Due to this, there are two viable paths for section 3 activities.

Path one is to conceptualize mechanisms that incorporate additional safety items into the baseline cord lock solutions. This includes retro-fit solutions, and/or cord management options for the lower cost products. This will maintain the cord lock system's low-cost nature while improving safety.

Path two is to address specific concerns or cost challenges in the mid-range and high-end products. This may drive consumer adoption away from the lowest-priced options. The cord loop showed good promise in cost, but poor execution in the examples evaluated.

Section 3 summarizes new concepts for these mechanism types to address both paths listed above. The concepts are vetted for cost and feasibility to address the specific concerns outlined in sections 1 and 2 of this report.

3 Options Development Discussion

3.1 Introduction

The objective of phase 3 was to develop options for potential window covering technologies and analyze these ideas against existing baseline products to identify potential improvements in product safety, cost, and performance for corded operating systems. This section also includes comparative analysis of design ideas to the cost estimates of similar mechanisms documented in phase 2.

New ideas and analysis for the cord lock mechanism focused on reducing the length of the available pull cord while maintaining low costs and familiar operation. The effort towards improving the continuous loop focused on new mechanisms that removed the continuous loop as well as ideas to improve safety and user experience. New ideas for cordless operating systems focused on methods to reduce costs of cordless mechanisms so that these products are cost competitive with cord lock options.

Motiv created seven design ideas and evaluated overall feasibility for each design idea, in addition to using preliminary parts to generate a bill of materials to provide manufacturing cost estimates.

3.2 Methods

This section describes the design process and safety criteria used to develop the mechanism ideas and methods used to estimate the cost of components of the proposed technologies.

3.2.1 Alternative Design Generation Methods

Design options were generated based on the following design process within Acorn:

1. Brainstorming sessions with senior design and engineering participants to create a wide array of design solutions and ideas.
2. Vetting and evaluation of rough ideas to determine overall feasibility and impact against the design goals.
3. Selection of options with input from the CPSC staff to narrow our focus on fewer ideas that showed the greatest viability.
4. Refinement of ideas, with detailed analysis and costing evaluation.

3.2.2 Feasibility and Safety Evaluation Methods

Feasibility of mechanism alternatives was based on operating forces, such as product size, construction options, and materials, required for a variety of window covering styles. The graph below (Figure 19) shows the estimated user force input required to operate a window covering.

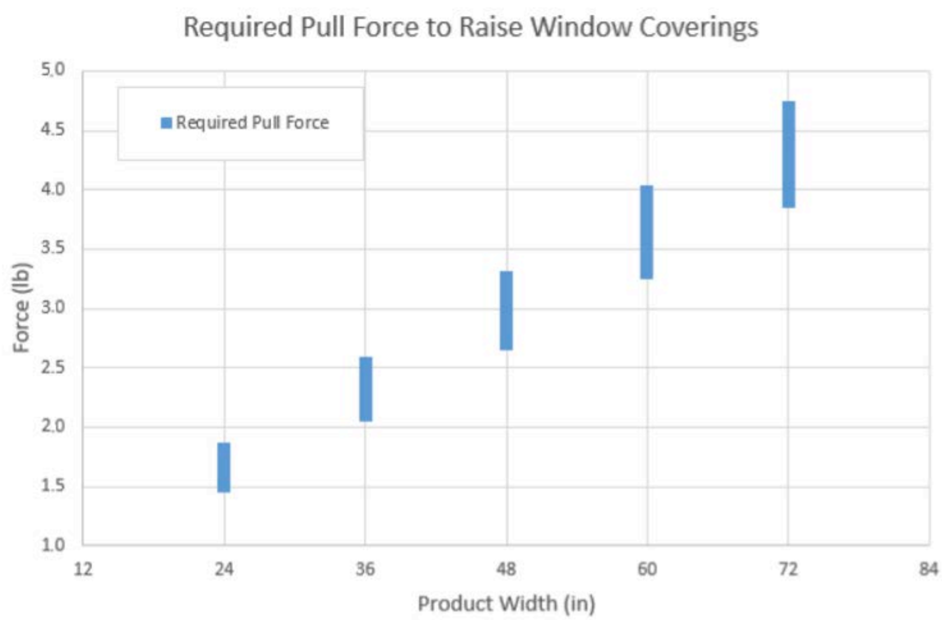

Figure 19. Required Pull Force to Raise Window Coverings

Motiv and Acorn also reviewed design ideas for ergonomic, feasibility, and safety considerations. The design ideas address reach and access issues using the feedback received from the focus groups.

Feasibility also included basic engineering calculations to determine the required spring forces, strength of materials, and overall material selection of the various ideas. These calculations drive the cost requirements of the components.

Using bi-weekly discussions with the CPSC staff, Motiv refined safety concerns and identified potential safety improvements.

3.2.3 Intellectual Property (IP) Evaluation Methods

Acorn conducted an engineering review and evaluation of the available intellectual property (IP) for each proposed design, based on patents identified in Phase 1. The patents may help determine the overall risk level to introduce and commercialize new ideas into the manufacturing process. A risk level was assigned to each proposed technology, based on existing products in the marketplace, products in different industries that are applicable to our intended design/solution, and overall age of the discovered IP. Recent IP ranked as high and older or expired IP ranked as low on the scale.

3.2.4 Cost Estimation Methods

Acorn identified a preliminary bill of materials (BOM) for the associated mechanisms using Acorn's estimation tools.

3.2.4.1 General Cost Assumptions

The cost estimates make certain assumptions regarding production of the new mechanisms in the manufacturing processes and labor costs. Specifically, Acorn assumed that products were mass-produced in similar volumes: the costing assumed production volumes of 1 million devices per year in China. The new mechanisms were estimated using the lowest price point components that meet the feasibility goals. For example, plastic material and injection molding were commonly used to estimate the lowest possible cost of the new design idea. Although the substitution of metal components may improve the feel and overall operating life, metal components would have greatly increased manufacturing cost.

Acorn used its internal cost estimation tool to estimate the cost of components, which produce estimates similar to those in the most common manufacturing processes. The estimates for hardware and commercial off-the-shelf (COTS) components, including screws and rivets, are based on typical industry costs and on Acorn's experience. For all proposed technology improvements, the cost of the fastener component represented a small portion of the overall estimated cost.

Acorn submitted preliminary Request for Quotations (RFQs) to it's network of suppliers in Asia to generate realistic cost estimates of expensive individual components, i.e., spring components. The vendor provided costs quoted in minimum order quantities (MOQ) of one million pieces per year. These prices, however, do not include any negotiation or long-term commitments to suppliers. Raw vendor data without additional price negotiation provided a conservative estimate for this development work.

3.2.4.2 Acorn's Plastics Estimator

Through years of experience and thousands of manufacturer parts, Acorn has built an Excel-based tool to estimate the cost of injection molded plastic parts (Plastics Estimator). The calculator takes into account a variety of information including the material costs, parts per run, manufacturing location, part volume, labor costs to mold the components, finishing costs, vendor profit, machine size, and cycle time. The Plastics Estimator also factors in vendor markup and finishing and assembly costs.

The resultant cost profile is presented in a graphical form. The calculated results from these worksheets have shown to be an accurate estimate of production injection molded plastic costs, within an error of 20%-30%. In order to estimate the component cost of a plastic component, several input parameters are required. The total component cost estimate is the sum of the following categories: material costs, labor costs to mold the components, finishing costs, and vendor profit. Figure 20 provides an example of how Acorn's Plastic Estimator calculates component costs.

Part Name Tilt Housing

Image: 

Material Cost	
Material	ABS (Cycolac)
Locale	China
Part Volume (in^3)	0.101
Runners Volume (in^3)	0.101
Waste/Reject %	5%
Material Density (lbs/in^3)	0.0379
Material Cost ($/lbs)	$1.10
Cost Per Part	$0.01

Molding Cost	
Projected Area (in^2)	1.1
# Parts per Run	1.00E+05
Estimated Machine Size (Ton)	150
% Shot Size Used	27.9%
Projected Area / machine size	44.0%
Cycle Time (sec)	30
Cavities Per Mold	20
Time for Run (days)	56.7
Machine Rate (hour)	$30.00
Setup Cost per Run	$500
DownTime (%)	2%
Cost Per Part	$0.02

Finishing and Assembly Cost	
Finishing (lot)	$0.00
Finishing (per part)	$0.00
Assembly Labor Rate ($/hr)	$7.00
Assembly Time (min per part)	0.0
Assembly (per part)	$0.00
Hardware/Insert Cost	$0.00
Total Overheads Per Part	$0.00

Profit	
Vendor/Tooler Markup	25%
Profit (per part)	$0.01
Profit (per run)	$665

Total Cost	
Material	$0.01
Molding	$0.02
Finishing and Assembly	$0.00
Profit	$0.01
Total Cost:	$0.033

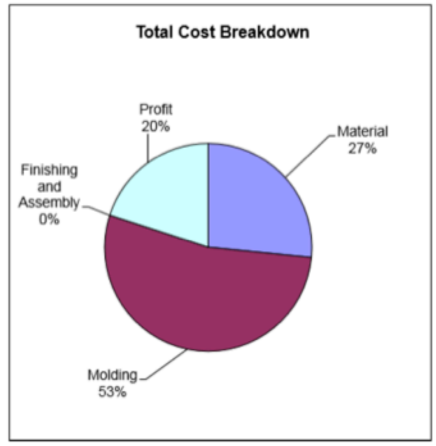

Figure 20. Example of Acorn's Plastics Estimator Worksheet

Material Costs

1. The material type of the part was estimated, or determined based on similar products in the market. The cost per pound of the input materials was estimated based on recent plastic pricing and commodity plastics pricing available on www.plasticsnews.com.

2. The amount of material required to mold the plastic part was estimated based on overall size, volume, or mass of the part. Additional material was included for the molding process such as runners and scrap.

Labor Costs

3. The number of cavities in the mold was set, based on one million per year target quantities.

4. The projected area of the part was estimated. The area and number of cavities determined the approximate molding equipment required. The size of the molding machine impacts the cost per hour to run the equipment.

5. The cycle time was estimated based on the part material, geometry, gating (or flow path of material into the part being molding), and wall thicknesses of the component.

6. Setup costs per run were included to setup the mold and qualify each lot of parts.

7. Lots of approximately 10,000 parts were used for all estimates, based on a yearly production volume of one million parts.

Finishing Costs

8. Finishing costs (trimming, manual inspection, painting) were added as required based on the burdened labor rate and estimated time to complete each manual operation. Very few parts required any manual labor input.

Vendor Profit

9. Vendor profit was also included at approximately 20-25% per part.

The fixed input assumptions for the cost modeling are:

Table 4 Fixed Assumptions For Cost of Modeling

Material & Labor Costs	Density	Required Clamping presure	US	Mexico	China	Malaysia	
			$35	$15	$7	$14	Burdened Labor Rate
	lbs/in^3	T/in^2	Material Cost, $/lb				
ABS (Cycolac)	0.0379	3			$1.10		
Nylon 6/6	0.0419				$2.20		
Nylon 6/6, 15% GF	0.0448				$2.27		
PC/ABS (Cycoloy)	0.0430	4			$1.65		
Polypropylene	0.0336	2			$0.73		
Polystyrene	0.0226				$0.93		

Machine Type	Reference: Max. Proj. Area (in^2)	Shot Size (in^3)	Machine Rates, $/hr US	Mexico	China	Malaysia
40	10.0	3.61			$25	
60	15.0	6.32			$25	
100	25.0	14.44			$30	
150	37.5	14.44			$30	
250	62.5	19.85			$35	
450	112.5					
500	125.0	90.23			$40	
650	162.5					
850	212.5	270.70			$50	
1200	300.0				$70	

3.3 Modifications, Applicability, and Limitations of Technology

New Mechanism Descriptions

The following section describes the modifications, applicability, and limitations of new mechanism technologies as well as existing pull cord, continuous loop, and cordless operating system improvements. In addition it summarizes potential intellectual property risks.

3.3.1 Pull Cord Design Options

As pull cords pose great safety risk, the new design options in the category of pull cord operating system investigate methods to eliminate loosely hanging pull cords or redesign the operating cords to prevent the formation of cord loops. Focus group participants reacted poorly to the perceived safety and overall aesthetic of the pull cord sample. The following ideas address this by reducing the risk of making a cord loop and changing the overall appearance.

3.3.1.1 Mechanism 1: Pull Cord Reel Accessory

3.3.1.1.1 Description of Product idea

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The first design alternative is an accessory device that spools excess cords within a housing unit. The device is mechanically simple, utilizing a constant force spring, clutch, and a button for releasing the brake on the cord. After installation to a cord lock mechanism, any excess pull cord will automatically spool into the device allowing the pull cord to always be contained when the window covering is not being actuated. In order to lower the product, the locking button must be pressed allowing spooled pull cord to pay out (unwind). Once the button is released, the device retracts to the top of the window covering. The internal spring must be able to rotate the spool as the cord is reeled into the mechanism. A 1⁄4 pound constant force spring would meet this requirement. Figures 21 and 22 show the mechanism design and operation, respectively.

3.3.1.1.2 Safety and Applicability Evaluation

A safety evaluation reveals that, by automatically returning to the head rail area, the device is kept out of reach of children. This mechanism is promising because it is a retrofit device that can work with any existing pull cord product already in the user's home. This device can be incorporated into a window covering and purchased as a complete unit or as an add-on accessory

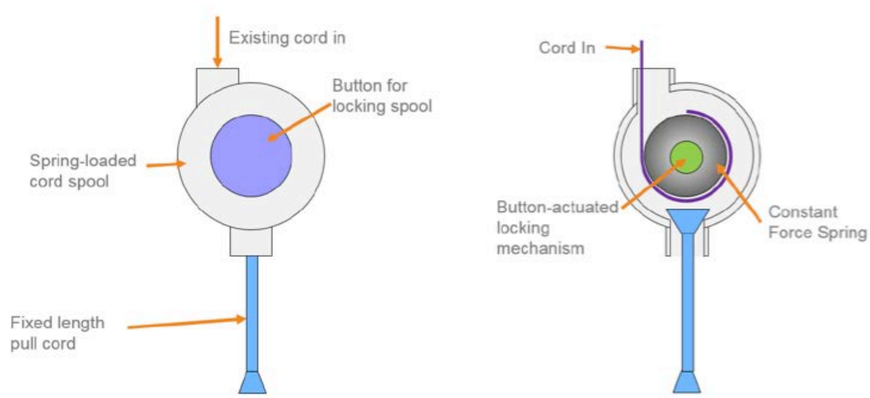

Figure 21. Mechanism 1 Design

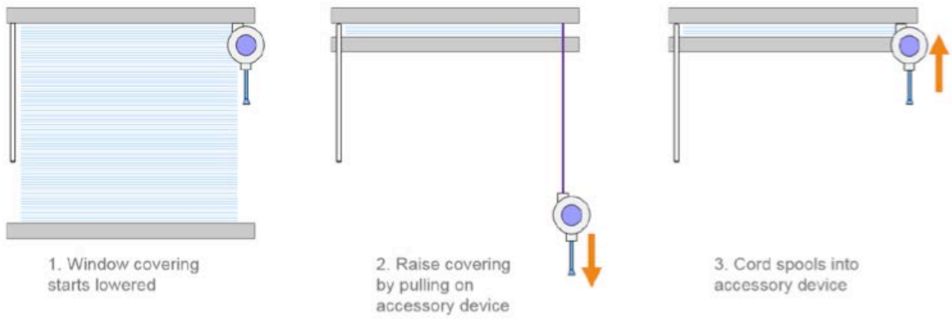

Figure 22. Mechanism 1 Raising Operation

There are no major concerns to integrate this safety mechanism into different width window coverings. The force on the spool and lock mechanism must be strong enough to match the user input forces. Preliminary material strength analysis has shown the estimated 1.5 inch to 2.0 inch diameter spool size and locking mechanism can meet this requirement.

Key functional requirements in a final design will include: retraction speed, ergonomics of the handle, access height, and minimization of the overall spool size. Feel and appearance of this device are critical to matching potential room décor environments.

By relocating all controls of the window covering to the top 8 inches to 12 inches of the window opening, low-hanging pull cords can be eliminated. This does create a potential reach issue for shorter users and complicates access behind furniture and/or very tall windows.

3.3.1.1.3 Intellectual Property

The IP risk of this mechanism (Figure 23) is quite high and is ranked as level 8.

Figure 23. Mechanism 1 IP Risk Rating

This mechanism may have some conflicts reaching the market for a number of reasons. As mentioned earlier, a patented product exists (#5,762,281) that performs a similar function to this design idea. The patent for the similar product expired. Thus, manufacturing a product similar to it could be inexpensive and well-reviewed. There is a large variety of IP both inside and outside of the window covering market. However, a large portion of it is expired (Figures 24 and 25).

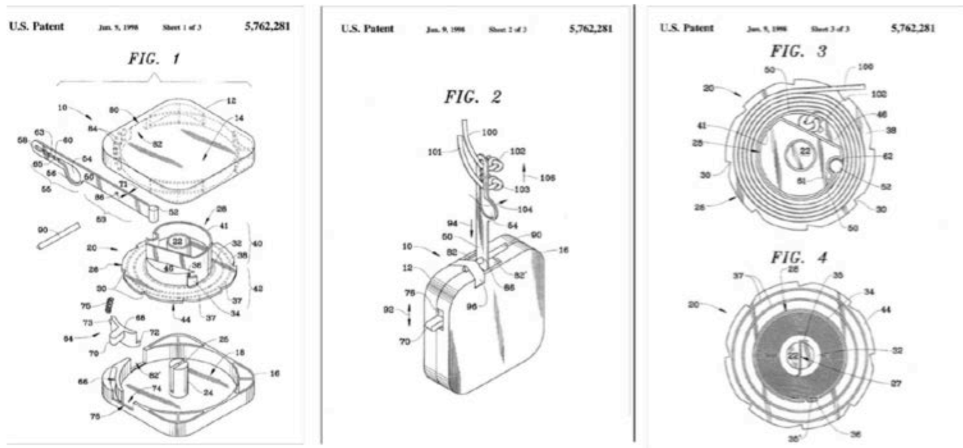

Figure 24. Competitive Expired IP for Mechanism 1

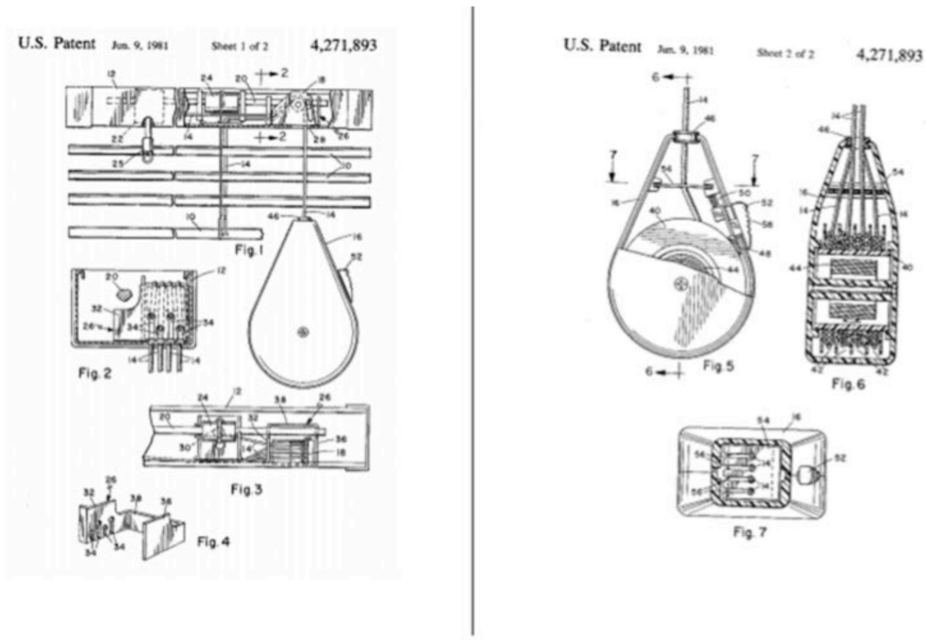

Figure 25. Competitive Expired IP for Mechanism 1

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3.3.1.2 Mechanism 2: Mounted Cord Reeling Accessory

3.3.1.2.1 Description of Product idea

The second pull cord design mechanism retracts excess pull cord. The mechanism is mounted to the windowsill or wall, below the window. The result is that the operating cord will remain accessible at all times but will be kept under tension significantly reducing the chance of loops forming. Mechanism 2 also has an integrated cord lock. The operation is similar to that of existing cord lock products, e.g., pulling the actuation cord down will raise the window covering and spool the pull cord into the device. Pulling the actuation cord to the side will release the cord lock mechanism in the head rail and the lower mechanism, allowing the window covering to be lowered. Figures 26 through 28 show the design idea and operation.

3.3.1.2.2 Safety and Applicability Evaluation

This mechanism controls the free-end of the traditional pull cord product – and could enable a major safety improvement in the product category. This device will remove control and contain the additional cord (no spooling on the floor, no user dependency to drape the excess cord). A constantly tensioned pull cord still exists in this concept, but since it is always under tension it would be more difficult to form into dangerous loops.

This potential device is versatile because it can be used with all cord lock sizes. Additionally, to improve safety, it can be marketed as an add-on device that can be used on any existing cord lock products.

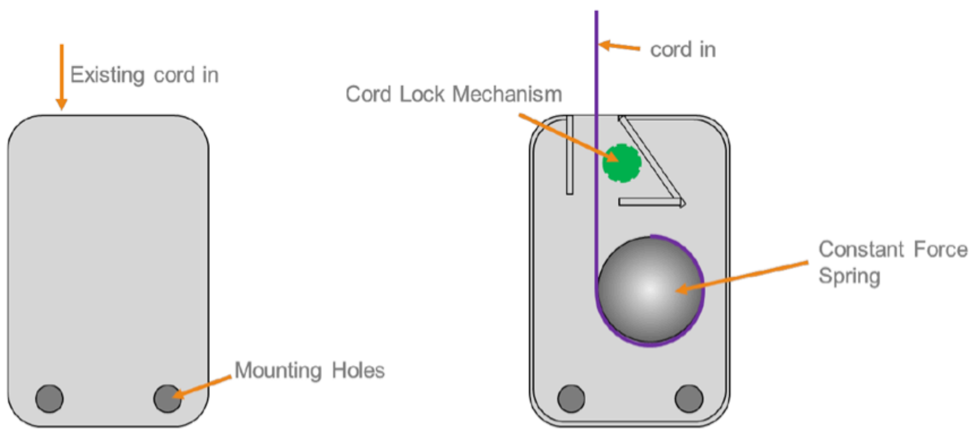

Figure 26. Mechanism 2 Design

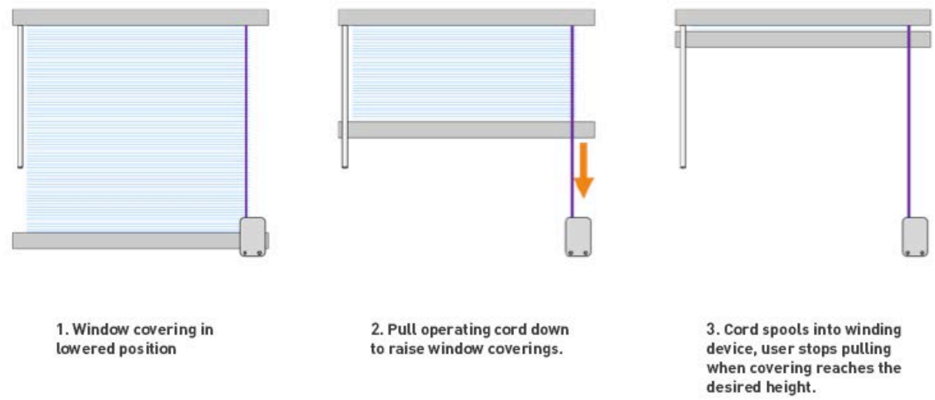

Figure 27. Mechanism 2 Raising Operation

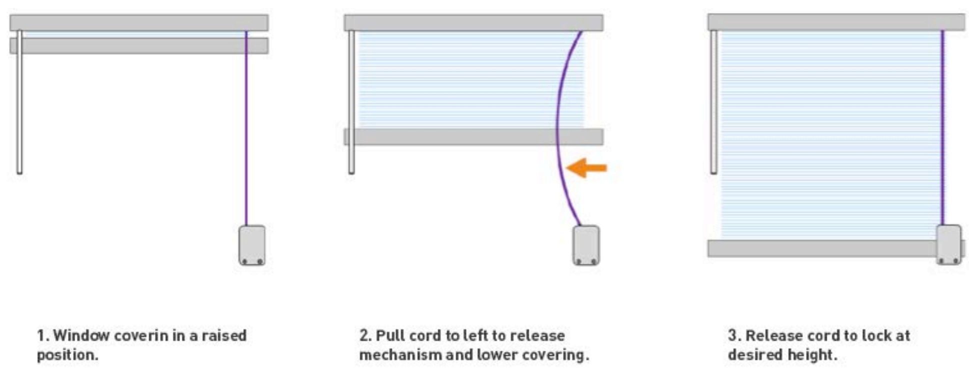

Figure 28. Mechanism 2 Lowering Operation

The spring selected must be strong enough to rotate the spool as the cord is reeled into the mechanism. A 1/4-pound constant force spring would meet this requirement. Because this mechanism requires no change to high strength components in the cord lock, it should be scalable to a variety of window covering sizes, widths, and weights.

Access and reach remain relatively unchanged for this mechanism, as the operator interface area is consistent and low on the window. The single cord is always under tension, which reduces the possibility of the cord becoming slack.

The visual appearance of this device can be a challenge to consumer acceptance since it requires a direct mount on the windowsill or below the window.

3.3.1.2.3 Intellectual Property

The IP risk of this mechanism (Figure 29) appears to be moderate and is ranked as level 6.

Figure 29. Mechanism 2 IP Risk Rating

While there are no identical products on the market, the Blind Winder mentioned in mechanism 1 has a similar construction to the overall idea in mechanism 2. The proposed new mechanism may also conflict with some cord tensioning patents (Figure 30) that exist for continuous loop cord products. Although there is a relatively large amount of competitive intellectual property inside and outside of the window coverings market, most of it is expired.

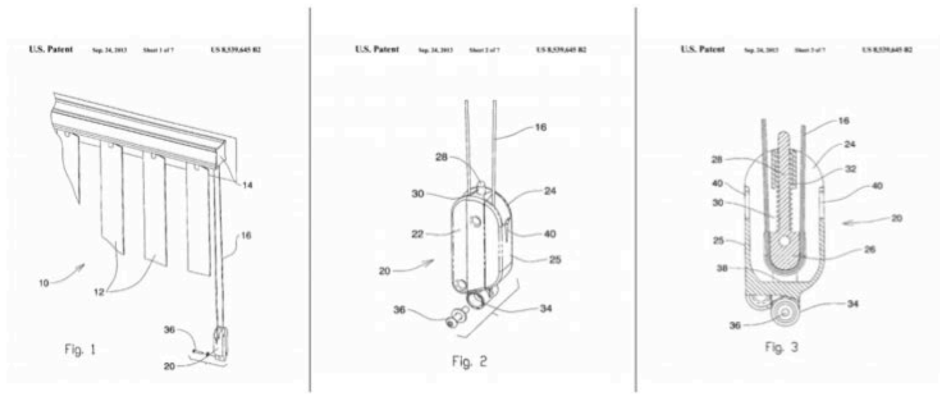

Figure 30. Existing IP Similar to Mechanism 2

3.3.1.3 Mechanism 3: Integrated Cord Reduction

3.3.1.3.1 Description of Product idea

The third design alternative (Figure 31) is a simple mechanism that gathers the two to four cords inside a standard cord lock mechanism and disperses a single pull cord for the user to interact with. This is accomplished by the addition of a simple spool inside the head rail housing and incorporating the components of the standard cord lock mechanism. Since window coverings come in a variety of sizes, i.e., width and length, the pull cord length and spool geometry will need to be adjusted to meet functionality requirements.

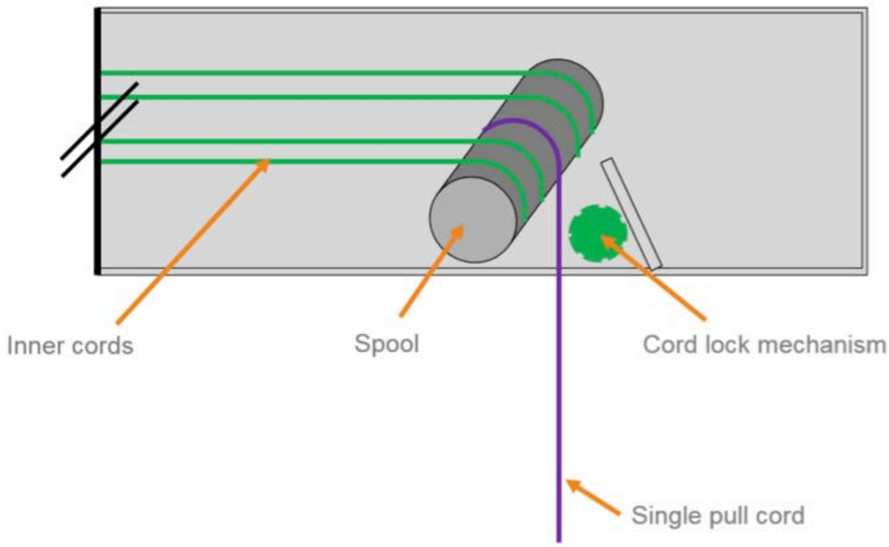

Figure 31. Mechanism 3 Design

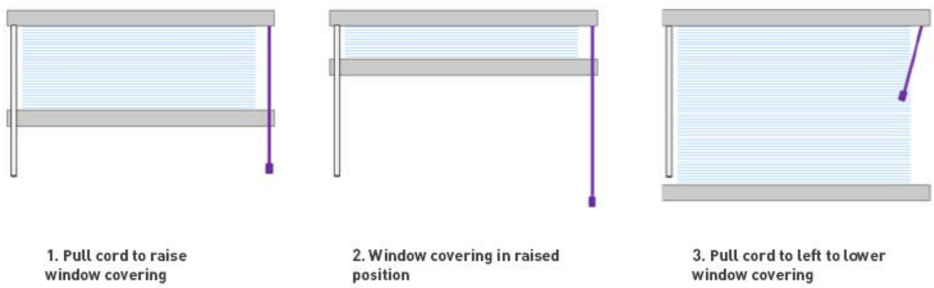

Figure 32. Mechanism 3 Raising and Lowering Operations

This design alternative can present a single, high-quality pull cord to the consumer. The design can be used on window coverings of all sizes to facilitate operation and potentially improve the user experience.

The spool mechanism that interfaces with the individual inner cords must be rigidly attached to support the high loads. The design idea would not require redesign of the head rail or other support mechanisms: the structural head rail and support structure used in existing window coverings appears adequate to support the spool mounting loads required.

Adjustment of left-right balance could be difficult with a pull cord because this alignment adjustment would likely need to be done at the factory during construction of the product. Additional mechanisms and access could be provided for the user to adjust the appearance beyond what is shown in the preliminary design images. An adjustment with a single pull cord could be more difficult to the user than the current multiple pull cord solution.

3.3.1.3.2 Safety and Applicability Evaluation

This idea does not eliminate the low-hanging pull cords, and provides only marginal improvement in overall safety. Because the operating system is identical to standard cord lock products, user adoption is expected to be straightforward and low risk.

3.3.1.3.3 Intellectual Property

The IP risk of this mechanism (Figure 33) appears to be low and is ranked as level 4.

Figure 33. Mechanism 3 IP Risk Rating

There are a number of add-on cord reduction products (Figure 34) on the market, but no solutions that integrate that functionality into the head rail itself. The few intellectual property patents for cord lock mechanisms designed into the head rail are expired, and there is little competitive intellectual property outside of the window coverings market.

Figure 34. Example of Mechanism 3 Competitive Accessory Product **

3.3.1.4 Mechanism 4: Elastic Pull Cord

3.3.1.4.1 Description of Product Idea

The fourth design option (Figure 35) involves replacing the operating cord with an elastic pull cord that will coil on itself when not in use. The elastic cord allows the cord to retract out of reach of children when not in use, and reduced the risk of the cord forming dangerous loops. The operation would be identical to standard cord lock mechanisms after the elastic pull cord is pulled taut.

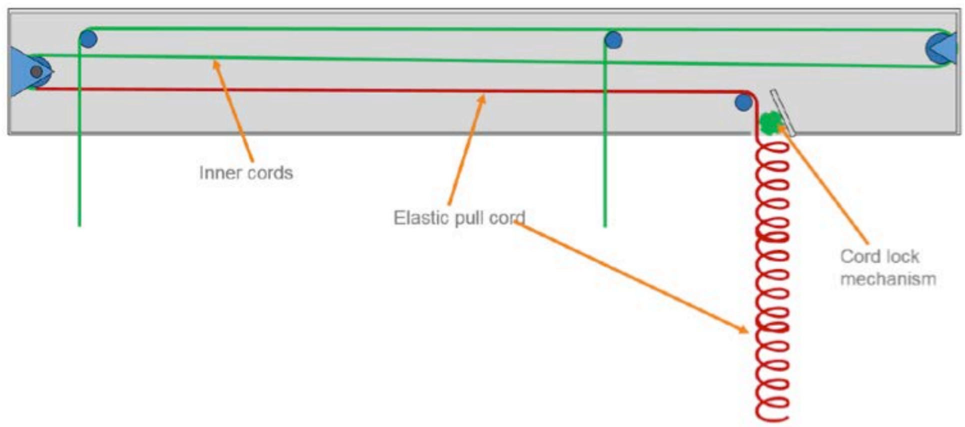

Figure 35. Mechanism 4 Design

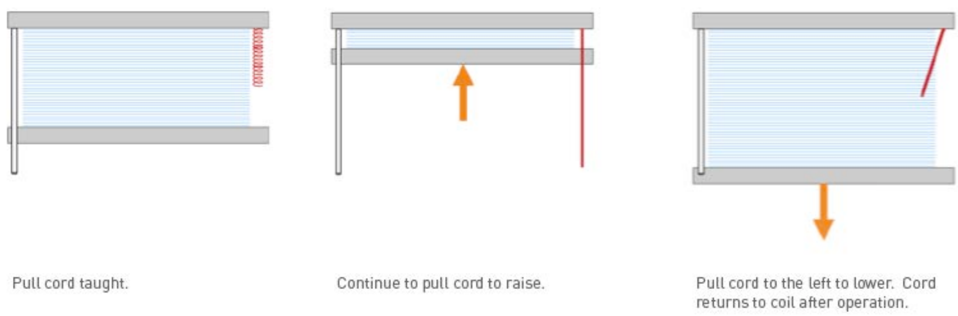

Figure 36. Mechanism 4 Raising and Lowering Operation

The length of the pull cord depends on the size of the window covering, and additional pulleys within the head rail may be required for larger products. The elastic pull cord selected should take about ¼ pound to extend. The pull cord must be completely taut before actuation of the mechanism can occur. Consumers may have a negative perception of the product, as they may need to pull a significant length of elastic cord before engaging the cord-lock mechanism and releasing the window covering. Small adjustments to lower or lift the window covering could be challenging since large amounts of cord must be pulled before the mechanism releases the cord.

3.3.1.4.2 Safety and Applicability Evaluation

The elastic cord dramatically minimizes the risk of the loose/dangling pull cord since the only exposed cord is 8-12”. There is also no user input required (elastic cord is self-retracting), minimizing the risk of unintentional cord positions and dangling cords left in the poor locations. This could be a major improvement in overall safety of the pull cord solution.

The reduced reach of the access cord can be a significant obstacle is applicability of this mechanism across all potential situations. The shortened cord could be difficult to reach for shorter customers and reaching over other furniture in the room (couches, tables). Making the retracted height longer is in direct contradiction to the safety reduction; the longer the cable the better reach access but this would increase the risk of entanglement and loop formation.

If a child pulls the elastic cable, the elastic will elongate and could also minimize the strangulation risk.

When released, the taught elastic cord creates an additional safety concern. Based on the final material and cord selection, this cord could quickly retract (or slip from user's hand) creating an uncontrolled whip condition.

The elastic cord interface to the cord-lock mechanism is a potential wear issue in this design. The elastic cord will be trapped between the friction elements of the lock. This is often a knurled surface and may damage the elastic cord casing. The elastic nature of the cord will want to expand and contract locally around the knurled surface during actuation, which can cause additional abrasion to the elastic casing. Alternative friction solutions may need to be developed based on the final cord material selection.

3.3.1.4.3 Intellectual Property

The IP risk of this mechanism (Figure 37) appears to be high and ranked as level 9.

Figure 37. Mechanism 4 IP Risk Rating

While there are no competitive products on the market, there is a high IP risk rating as there is an individual inventor who has recently been granted a patent on this design and is trying to bring the product to market. No intellectual property conflicts outside of the window coverings market were found.

3.3.2 Continuous Loop Cord Design Options

The continuous loop products garnered mostly negative feedback in the focus groups. Motiv and Acorn suspect this was because the chosen sample mechanisms were not the easiest to grasp and pull. For this reason the design options for the continuous loop cords category focus on mechanisms that improve not only safety, but also ergonomic issues such as improving grip and reducing the range of motion needed to raise and lower a window covering.

3.3.2.1 Mechanism 5: Simple Wound Cord

3.3.2.1.1 Description of Product idea

The fifth redesign idea replaces the continuous loop operating system with two individual cords that are used to raise and lower the window covering (Figure 38). Each pull cord is also geared to reduce the overall travel of the cords, allowing them to be shorter. Additionally, the device includes an anti-back drive clutching mechanism to prevent the window covering from lowering by its own weight. The ergonomics of the one-handed operation is straightforward: the consumer pulls one cord to raise the product and another cord to lower.

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3.3.2.1.2 Safety and Applicability Evaluation

The redesign concept would require an increase in the force used to raise and lower the product through the gearing. The gearing and cord length may need to be adjusted based on the product dimensions. Figure 39 shows the mechanisms in the design concept and how to operate the design concept.

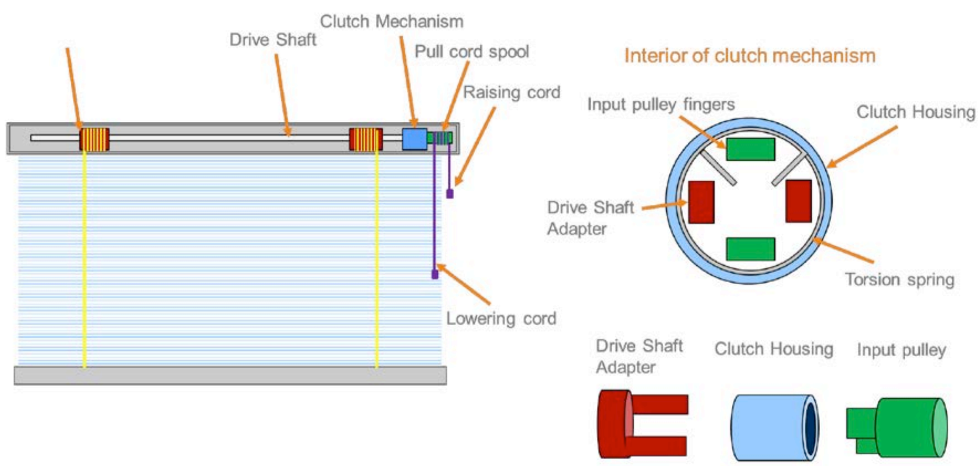


Figure 38. Mechanism 5 Design

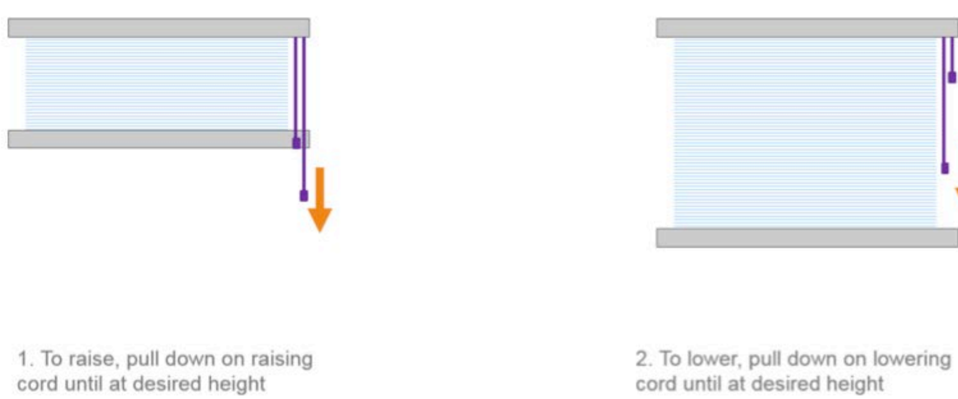


Figure 39. Mechanism 5 Raising and Lowering Operations

The gearing mechanism reduces the length of the exposed operating cord. The overall length of these cords is estimated to be between one-half and one-third of the overall travel height. For example, a window covering height of 60 inches would have the pull cords approximately 24 inches to 30 inches in length, the ends of which would rest 52 inches to 64 inches above the floor. Figure 40 shows the potential dimensions of the operating cord in relation to the floor.

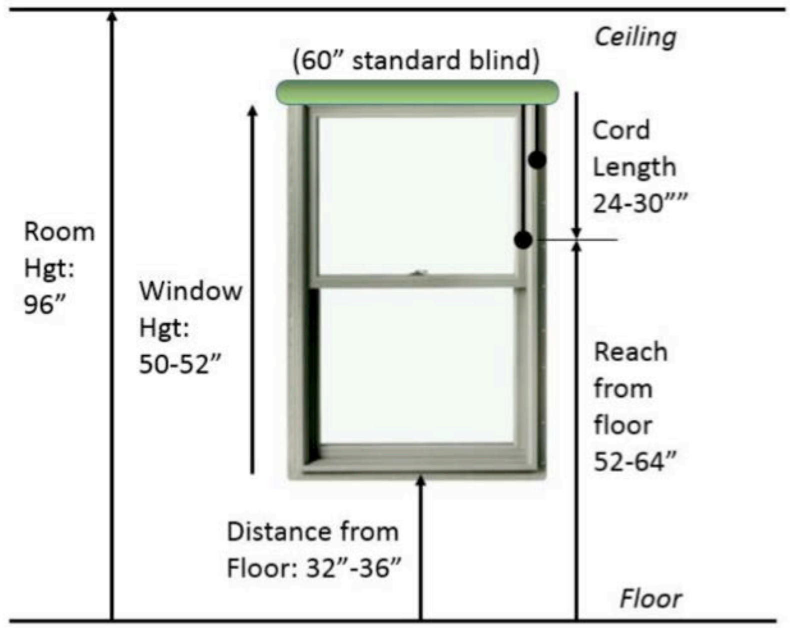
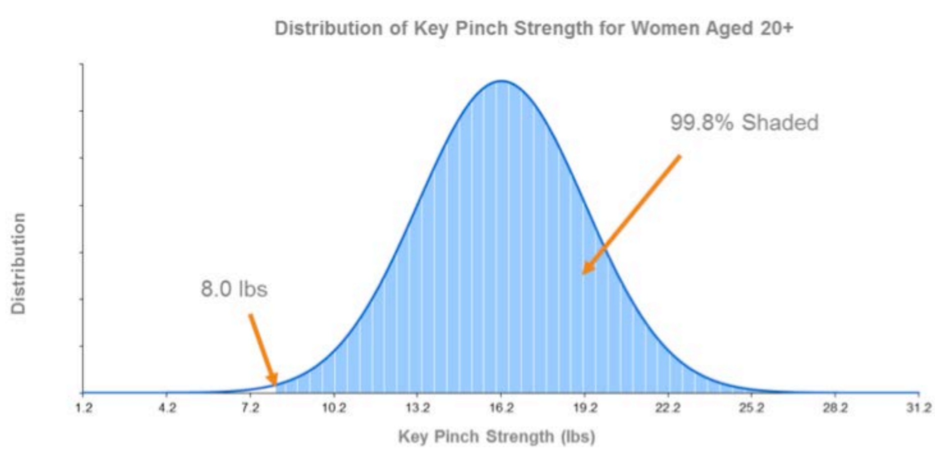


Figure 40. Mechanism 5 Reach Dimensions

The reduced cord/operating height is an improvement in potential device safety. The cord actuation point is now higher than the base of the window, and out of direct reach from a child. Like the elastic/retracting operating cord, there is a direct relationship between convenient reach height for adult operators, and minimizing the risk of unintended reach/operation from a child. A longer access cord would mean easier operation but a heightened safety risk. The proposed height in this mechanism (24"-30") would not meet a desired ~12" maximum length from the head rail. This proposed length (24"-30") may be reachable by a climbing child, or child standing on potential nearby furniture. The cords in this mechanism cannot be reduced below the proposed 24"-30" due to the proposed actuating forces described below.

In order to understand the mechanical feasibility of the geared mechanism, Motiv analyzed human factors data, including pinch force and pull strength, to determine the appropriate force that the user can apply to the device. Pinch force (Figure 41) was chosen as the relevant data set because it refers to the force a person can apply between their thumb, forefinger, and middle finger and was the most likely grip consumers would use when interacting with a pull cord or continuous loop cord. On average, most consumers can pull with a force value of 8 pounds, which represents the minimum female grip strength of 99.8% of the population (Grip and Pinch Strength: Normative Data for Adults, 1997. Virgil Mathiowetz).



original by W. F. Coleman 1997, adapted by H.S. Drier, 2000

Figure 41. Distribution of Key Pinch Strength for Women Over Age 20

Motiv also analyzed arm pull strength in the evaluation of the window covering actuation. Arm strength for comparable subjects was always greater than hand pinch strength: individuals have a higher force capability to pull with their arm than to grasp the cord between their fingers. Under high actuation loads, the cord is more likely to slip out of the users hand.

The analysis did not assume the user could wrap the cord around their hand or wrist to increase grip strength for high loads. Window coverings can be sold in variety of materials and sizes. The required force to raise the products is a result of the variance in weight as well as the efficiency and overall mechanical ratio within the raise and lower mechanism. The required pull forces are a function of the proposed mechanism solutions used to manipulate the window covering.

Figure 42 shows the required input forces used to raise or lower various window coverings relative to the maximum user force. All products below the 8-pound maximum user force line can be operated by the mechanism. Operating forces that intersect the maximum user force indicate some configurations of these window covering sizes can be operated by the mechanism. All of the dimensions below the maximum operating line can be operated within the user force limits, i.e., consumers will be able to operate 24 inch, 36 inch, and 48 inch wide window coverings as the user force required is less than 8 pounds. A light weight 60 inch width window covering can be operated within the 8 pound user limit, but some heavier variants of the same size cannot be operated within the user limit. Likewise, none of the 72 inch width window coverings can be operated within the 8 pound limit. The majority of window coverings can adopt this geared lifting mechanism. In products exceeding 72 inches in width, mechanism 5 would require user force exceeding 8 pounds.

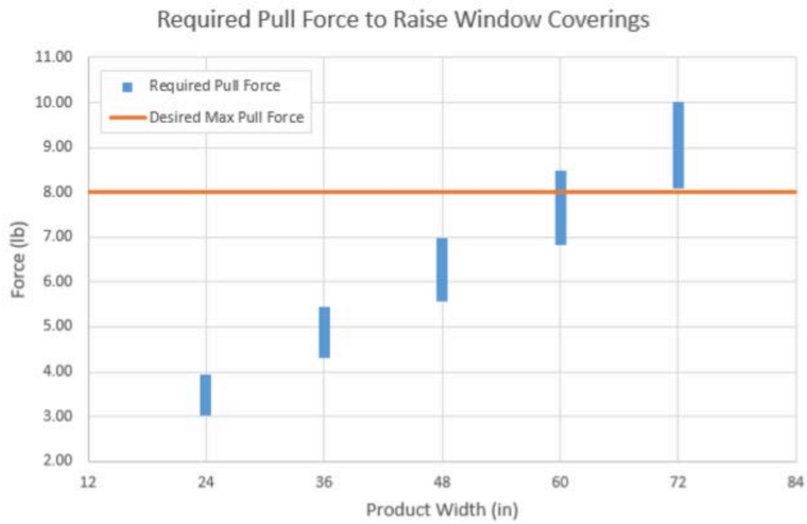


Figure 42. Required Pull Force to Raise Window Coverings

3.3.2.1.3 Intellectual Property

There are several dual pull cord products available in the market, but there appear to be few that replicate the geared cord functionality. This design alternative will likely compete with continuous loop cord window coverings because of the similarity of their mechanisms and operation. The IP risk of this mechanism (Figure 43) is rated as 4.

Figure 43. Mechanism 5 IP Risk rating

Although there are a small number of similar patents (Figure 44), most have expired. Additionally, there is little conflicting intellectual property outside of the window covering market.

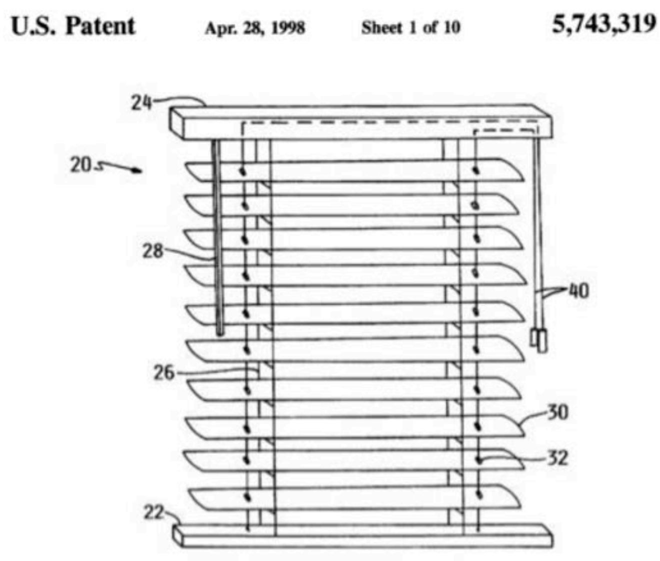


Figure 44. Mechanism 5 Example Expired IP

3.3.2.2 Mechanism 6: Fixed Cord Loop with Handle

3.3.2.2.1 Description of Product Idea

The sixth design option adds a handle to a geared continuous loop cord mechanism to reduce the distance the handle will have to travel to fully raise and lower the window covering. As with existing continuous loop operating systems, the cord loop will also require a tensioning device to prevent the formation of hazardous loops. However, Mechanism 6, features a handle that allows users to lift the window covering by pulling the handle in a downward motion. Similarly, users must pull the handle up to lower the product. The device also includes an anti-back drive clutch mechanism to prevent the window covering from lowering by its own weight. The operation of mechanism 6 is shown in Figure 45.

3.3.2.2.2 Safety and Applicability Evaluation

The handle itself could also be sold as an accessory device for existing loop cord products.

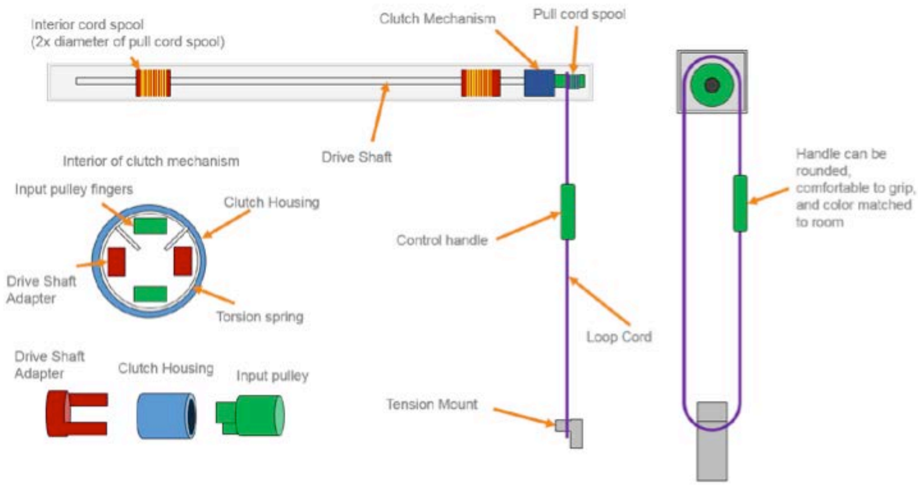


Figure 45. Mechanism 6 Design

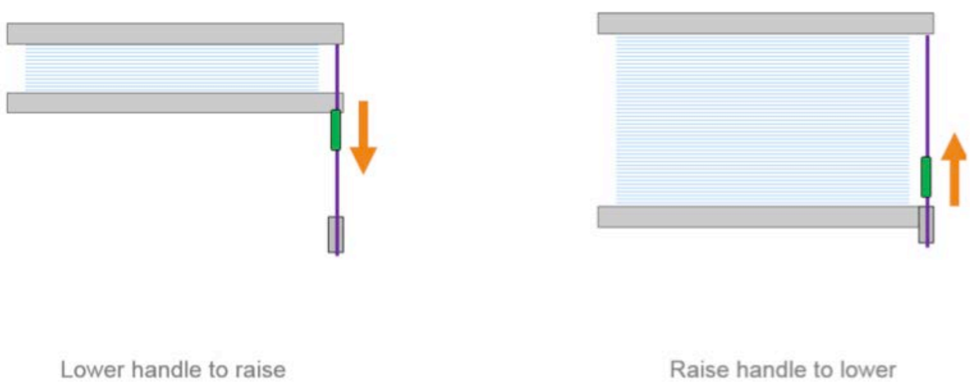


Figure 46. Mechanism 6 Raising and Lowering Operation

The proposed gearing and mechanical efficiency of mechanism 6 is comparable to that of mechanism 5 (Figure 46). Mechanism 6 is expected to operate on window coverings less than 48 inches wide. Window coverings that exceed 60 inches in width can exceed the operator input force, based on the pinch grip assumption.

The proposed handle does not impact the overall safety of the loop cord solutions on the market today. The mechanism still requires a fixed attachment low on window frame and would be accessible to a child. The tensioned loop is an improvement over loose cords and does maintain cords off the floor. The fixed loop also requires no customer action to safely store the cords at either end of operation.

3.3.2.2.3 Intellectual Property

The IP risk of this mechanism (Figure 47) appears to be relatively low and ranked as level 5.

Figure 47. Mechanism 6 IP Risk Rating

There are few products on the market that incorporate a handle into a loop cord design and very little conflicting intellectual property. There is, however, a need for a cord tensioning device, for which there are many competing products and patents on the market. There is little conflicting intellectual property for handles or loop cord tensioning devices outside the window coverings market. Figure 48 shows an example of a cord tensioner similar to the one used in Mechanism 6.

Figure 48. Example of Competitive Cord Tensioner Product Similar to Mechanism 6

3.3.3 Cordless Design Options

The cordless operating systems were well received by focus group participants. While this is positive, even the low cost cordless sample was 3-5 times the cost of the inexpensive cord lock offerings. In light of this, the design alternative in the cordless operating system product category focused on reducing the manufacturing cost of the cordless mechanism in order to be comparable to that of the low-cost pull cord technology.

3.3.3.1 Mechanism 7: Pulley Actuated Cordless

3.3.3.1.1 Description of Product Idea

The seventh idea explores a reduction in manufacturing cost of expensive cordless mechanisms by replacing the dual springs and gearing with a simple 3:1 pulley system (Figure 49). This proposed pulley system allows the use of a higher force and lower travel single spring. The spring is the primary driver in the overall cost and reducing the cost of this element would have a large impact on the overall costs. The proposed higher force spring requires a thicker material grade without using significantly more material. The design also utilizes capstan rollers that increase the friction on the system and allows a larger spring force to counterbalance the weight of the window covering. The mechanism is raised and lowered by moving the bottom rail up and down (Figure 50). This design solution requires a balanced or "tuned" system so the spring can react the specific window covering mass. Different springs may be required based on the window covering length, size, and materials.

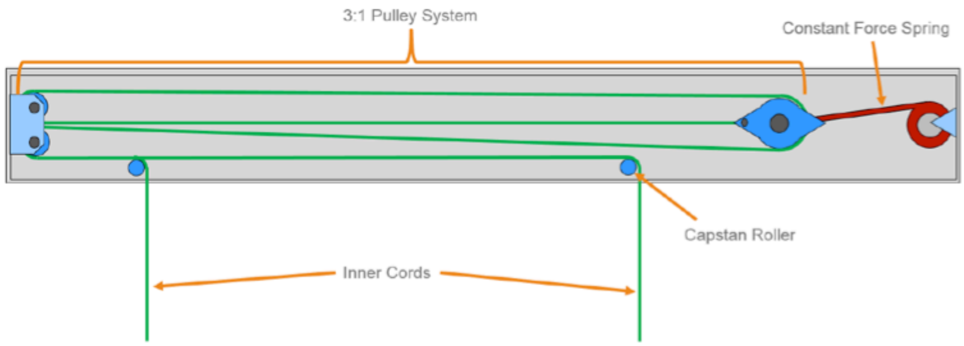


Figure 49. Mechanism 7 Design

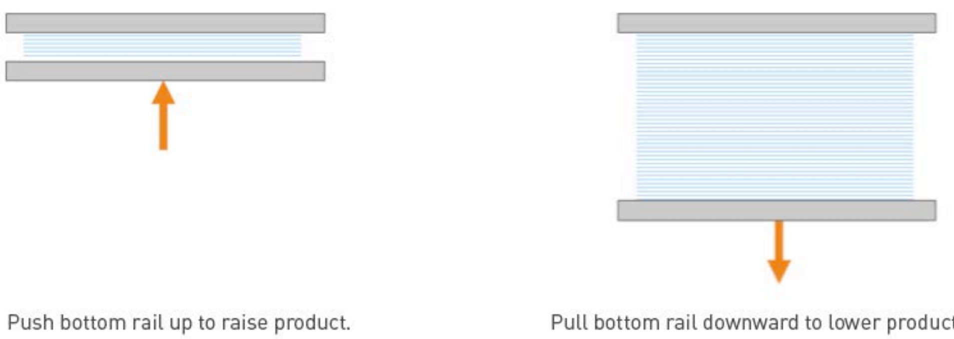


Figure 50. Mechanism 7 Raising and Lowering Operation

3.3.3.1.2 Safety and Applicability Evaluation

There is no strangulation hazard associated with operating cords as they are eliminated from the design of the product.

A range of weights was tabulated for different cordless width window coverings based on material and length. To support the mass of typical coverings, the proposed design includes capstan friction braking which allows the spring to react a larger range of weight. These large ranges in spring forces can be seen as the orange bars in Figure 51.

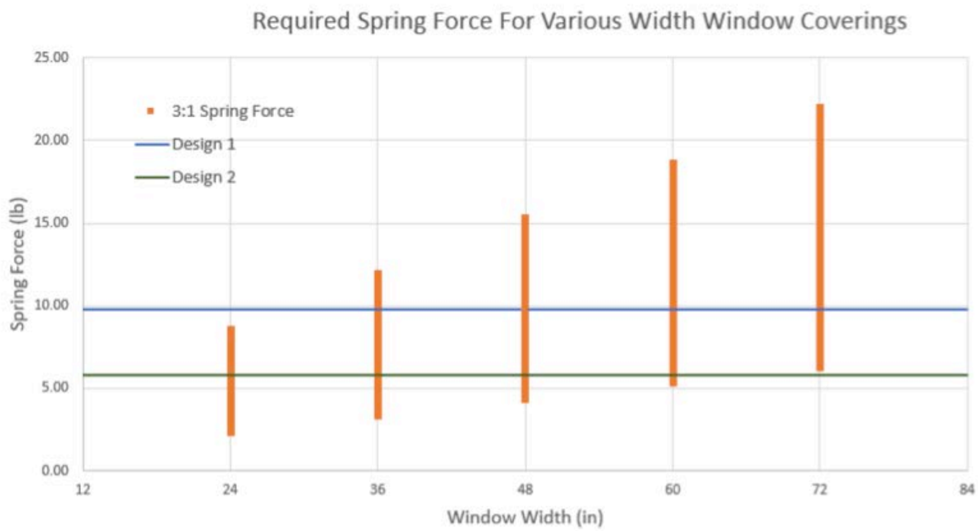


Figure 51. Required Spring Force to Operate Window Coverings

Design 2 has a lower overall spring force and is better suited for lower mass products. The spring design combination in design 2 can be used with products with widths of 24 inches or less and some products whose width is less than 36 inches wide. Spring design 2 cannot be used on products with a width of 48 inches, 60 inches, or 72 inches.

Design 1 has a higher spring force compared to that in design 2. The spring in design 1 cannot be used on products that are 24'' wide. Design 1 can be used with approximately one-half of products that are 48 inches wide and some products that are 60 inches wide.

The final spring selection will depend on the exact window covering size and materials or construction. A specific spring and force output would be required based on the product parameters. This data is plotted against two sample springs (design 1 and design 2) that were quoted for costing in this report. In mechanism 7 costing, the design 2 spring parameters were used for costing comparisons.

3.3.3.1.3 Intellectual Property

The IP risk of this mechanism (Figure 52) appears to be high and ranked as level 9.

Figure 52. Mechanism 6 IP Risk Rating

There are a large number of comparable products available from a variety of manufacturers and vendors. This results in some conflicting intellectual property (Figure 53) despite the fact that it uses a mechanism similar to the proposed gearing. The 3:1 rope system is often used outside of the window covering industry, and there are a number of similar products and patents.

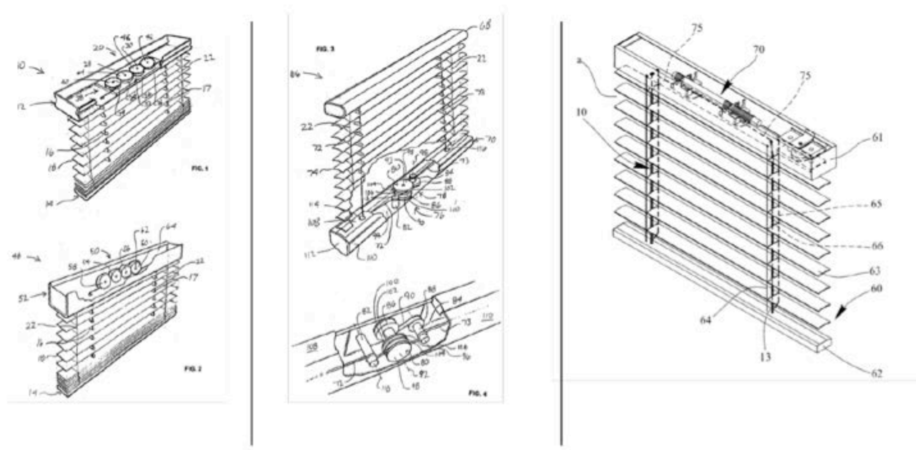


Figure 53. Competitive IP For Mechanism 6

3.4 Changes in Production Cost

In order to define the potential change in manufacturing cost of the new concepts, a preliminary bill of materials was built for each idea based on feasibility studies and functionality inputs. Mechanical analysis was used to estimate cost-defining characteristics of the parts involved such as materials, dimensions, and manufacturing processes. The work focused on identifying the lowest manufacturing cost options for each part in order to compare the new ideas against the existing products in the market. The costed bills of materials and corresponding charts can be found in the appendix of this report. The cost estimates may vary greatly depending on actual volumes, target quality levels/sale price, materials, and cost fluctuations.

The projected manufacturing costs of the new concepts were compared to the existing products to determine any change in cost. Conceptually, the total cost represents the cost of goods sold from a manufacturer's perspective. The total cost is calculated as the sum of the costs associated with individual parts.

The cost of static components, such as head rail, slats, and mounting hardware, are excluded as these non-mechanism parts are highly dependent on the finish and quality of the window covering, and have negligible impact on the mechanism costs.

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To reduce the impact of the large mark-up differences between sale price of the baseline samples and the estimated cost of the components, the lowest quality components and manufacturing practices were used as the primary comparison between the new ideas and the baseline products. Although mark up is unknown, Motiv estimated the retail price of components for design concepts (based on preliminary volumes, material selection, and part definition) using the same process as described in section 3.2. The cost comparison compares the cost associated with the raising and lowering mechanisms. The analysis excludes comparisons of cost of tilt mechanisms, as all products do not have tilt option.

The following sections analyze the cost of components by operating system.

Comparison Between Operating Systems

Figure 54 compares manufacturing costs of existing products with manufacturing costs for design concepts identified in phase 3 (mechanisms 1 to 7). The baseline (existing products) were selected from the lowest cost commercial solution in each operational category for each concept.

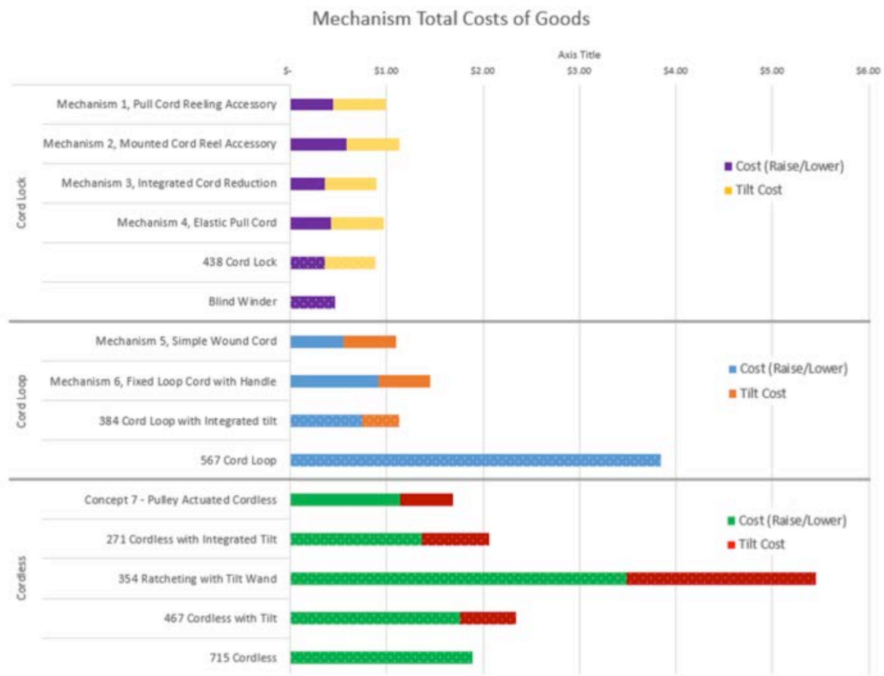

Figure 54. Mechanism Total Costs of Goods

In the collected samples, the pull cord product represents the least expensive type of operating system while the cordless products represent the most expensive type of operating system. The quality and materials of components within the product can also affect the price.

The lowest retail price loop cord product in our sample size was $150, compared to the pull cord price of $3.99 (product 438) and a cordless retail price of $14.97 (product 715).

The cost and complexity of parts may affect the retail price of product. The design options show that changes to the manufacturing process can result in continuous loop products using more complex mechanisms. In this case, the retail price may increase. However, the opposite is also true. Using less complex components may reduce the retail price of the continuous loop product.

3.4.1 Pull Cord Cost Comparisons

Table 5 shows the relative cost comparisons between the pull cord design options and the baseline product. Product 438 was selected as the cord lock baseline with an estimated cost of $0.88 for the following comparative analysis. The cost of the raise/lower mechanisms in the third and fourth mechanisms, the cord reduction and elastic coiled cord devices are approximately equal to that of the baseline model device (438 Cord Lock) because the similarities in their cord lock mechanisms. Mechanisms 1 and 2 are higher than the baseline due to additional components.

The Blind Winder product is sold as an accessory and has no associated tilt costs included. The cost of parts used to raise/lower mechanism in first two design alternatives (the cord reeling accessory and the mounted cord reeling accessory) is approximately the same as that of the Blind Winder product currently sold in the market.

Table 5 Pull Cord and Baseline Product Cost Comparison

Mechanism (and Product)	Estimated Cost of Mechanism	Estimated Cost of Mechanism Percent Increase	Estimated Retail Price, Including Mark-Up
Baseline (438 Cord Lock)	$0.884	0%	$3.99
Mechanism 1: Reeling Accessory	$0.990	12%	$4.47
Mechanism 2: Mounted Reeling Accessory	$1.126	27%	$5.08
Mechanism 3: Cord Reduction	$0.896	1%	$4.04
Mechanism 4: Elastic Coiled Cord	$0.964	9%	$4.35

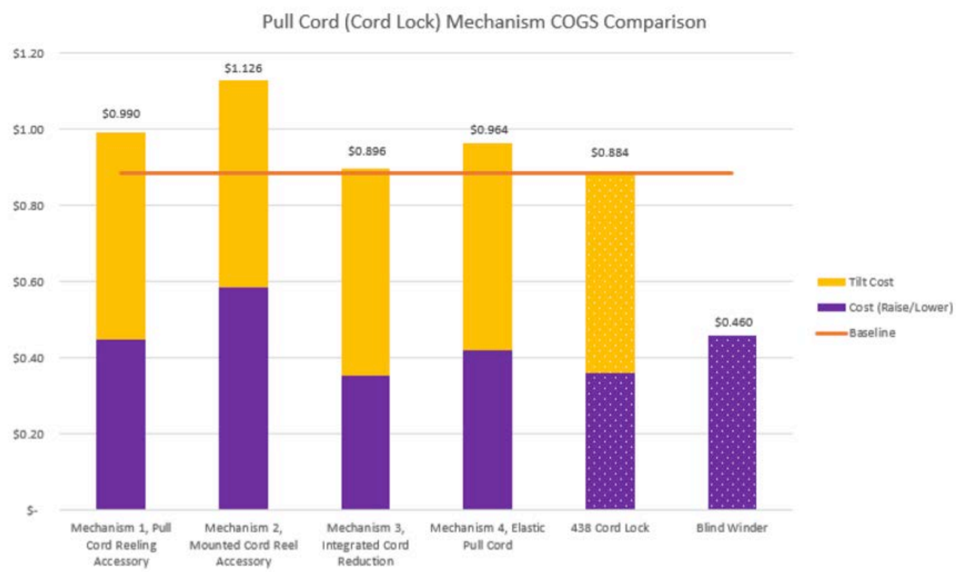

Figure 55. Pull Cord (Cord Lock) Mechanism COGS Comparison

Table 6 shows the estimated increase in cost for each cord lock technology relative to the baseline cord lock product.

Table 6 Cord Lock Mechanism Cost

Mechanism (and Product)	Estimated Cost of Mechanism	Estimated Cost of Mechanism Percent Increase	Estimated Retail Price, Including Mark-Up
Baseline (438 Cord Lock)	$0.884	0%	$3.99
Mechanism 1: Reeling Accessory	$0.990	12%	$4.47
Mechanism 2: Mounted Reeling Accessory	$1.126	27%	$5.08
Mechanism 3: Cord Reduction	$0.896	1%	$4.04
Mechanism 4: Elastic Coiled Cord	$0.964	9%	$4.35

As previously mentioned, the cost only reflects the mechanism assemblies. The estimated retail price of new mechanisms assumes that a one percent change in baseline product will correspond to a one percent change in retail price. Mechanism

1 represents a 12% increase in cost compared to the baseline model. This is calculated as:

(Mechanism 1 Cost – Baseline Costs) / (Baseline Costs) = (0.990-0.884)/0.884 = 12%

Motiv assumes this 12% change corresponds to retail price increase of 12%, including mark up. Thus, the estimated retail price, including mark-up, is $4.47 ($4.47 = $3.99 + 0.12 x $3.99).

The cost of parts in Mechanism 2 shows a substantial increase over the baseline product (27%).

Mechanism 1 has a lower estimated cost than mechanism 2 even though their internal constructions (tensioned spool) are similar. Mechanism 1 omits the cord lock components in mechanism 2.

Mechanism 4 costing is highly dependent on the elastic pull cord quality and consumer acceptance. The mechanism is currently estimated at an increase of approximately 9% in the cost of materials.

Mechanism 3 shows relatively flat cost increases but offers low improvement in safety performance.

3.4.2 Continuous Cord Loop Cost Comparisons

Figure 56 shows the relative cost comparisons between continuous loop design options and continuous loop baseline product. Product 384 was selected as the continuous loop baseline with an estimated mechanism of $1.13 with a retail price of $150.

An additional loop cord option (567 Loop Cord) is included for comparison of the cost between existing products. The mechanism cost of this product was significantly higher than the baseline: the cost of components used to raise and lower the product was more than double that of the baseline model. The large cost increase is due to the quality of components used in the assembly and inclusion of large molded plastic components in the handle/actuator design.

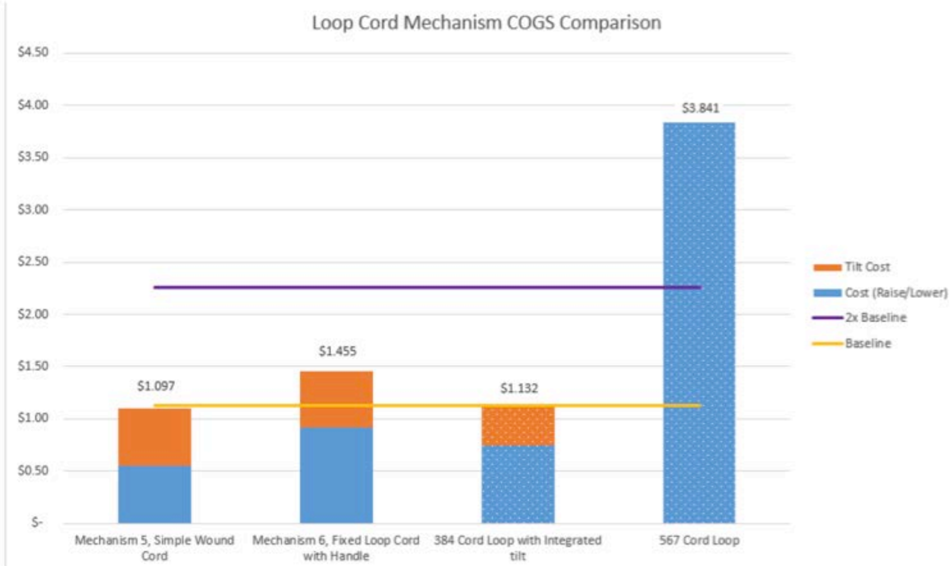

Figure 56. Cord Lock Mechanism Cost Comparison

Mechanism 6 is the most expensive proposed option due to the cost of the larger injection molded plastic parts that make up the handle.

Table 7 Continuous Loop Mechanism Cost

Mechanism/Product	Estimated Mechanism COGS	% Increase in Mechanism COGS	Estimated Sale Price ($) includes mark-up
Baseline (384 Loop Cord)	$1.132	0%	$150.00
Mechanism 5: Simple Wound Cord	$1.097	-3%	$145.36
Mechanism 6: Fixed Loop Cord With Handle	$1.455	29%	$192.80

Mechanism 6 is the most expensive proposed option due to the cost of the larger injection molded plastic parts that make up the handle.

3.4.3 Cordless Cost Comparisons

Figure 57 shows the relative cost comparisons between cordless design options and cordless baseline product. Product 271 was selected as the cordless baseline with an estimated mechanism of $1.36 with a retail price of $15.

Additional cordless examples are included for comparison to show a large range of current mechanism costs and retail sales price of this mechanism style.

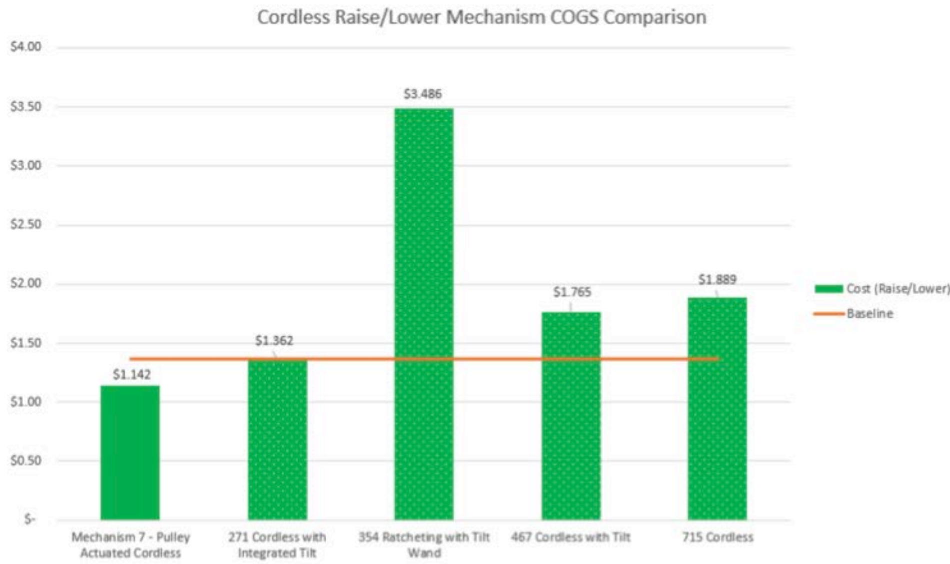

Figure 57. Cordless Raise/Lower Mechanism COGS Comparison

Table 8 shows the estimated cost of mechanisms and estimated price of the proposed mechanism compared to the baseline products.

Table 8 Cordless Raise/Lower Mechanism Cost

Mechanism/Product	Estimated Mechanism COGS	% Increase in Mechanism COGS	Estimated Sale Price ($) includes mark-up	Estimated Mark-up (Sale $/ Mechanism COGS $)
Baseline (271 Cordless)	$1.362	0%	$14.97	1099%
Mechanism 7- Pulley Actuated Cordless	$1.142	-25%	$12.55	1099%
Baseline (354 Cordless)	$3.486	240%	$190.00	5450%
Baseline (467 Cordless)	$1.765	46%	$81.90	4640%
Baseline (715 Cordless)	$.1.889	60%	$65.00	3441%

Mechanism 7 shows a 25% reduction in the expected mechanical costs compared to the baseline product.

3.5 Competitive Analysis of Durability (current vs. implemented changes)

Based on the conceptual mechanism designs, Motiv reviewed the expected functionality and durability of the proposed options. Since these are still in early stage development, the focus of the analysis was on user interaction with the proposed mechanism and critical component interfaces.

Each mechanism type is discussed in detail in the following sections.

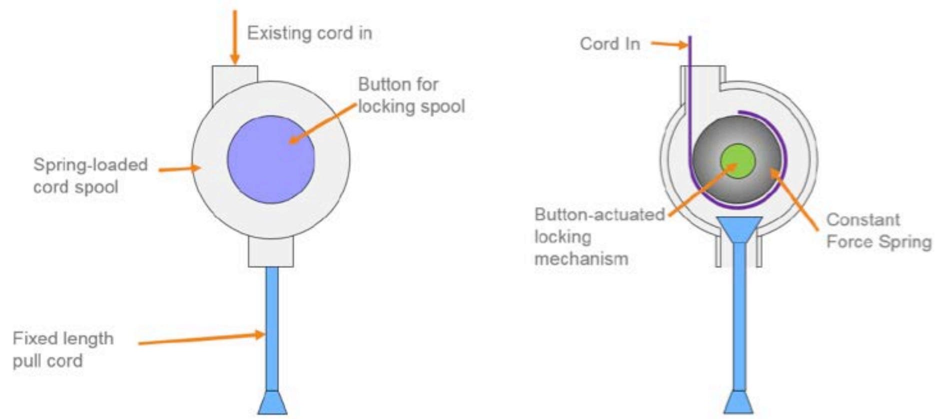

Figure 58. Mechanism 1 Design Pull Cord Reel Accessory

The pull cord accessory operates under both high and light loads. When the window covering is raised or lowered by pulling on the fixed length pull cord, the accessory must resist the actuation force or the existing cord will simply unspool and the window covering will not raise or lower. The button actuated locking mechanism and detents are subject to wear and should be designed with sufficient safety margins. As the user interacts with the fixed pull cord, there is stress created where the cord connects to the housing; overtime this stress creates a potential failure point. An internal knot or strain relief within the housing would be required and the selected cord material must be of sufficient tensile strength. The light loads occur during cord retraction and during movement of the accessory up to the top of the window covering. There are no significant durability concerns for intended use conditions.

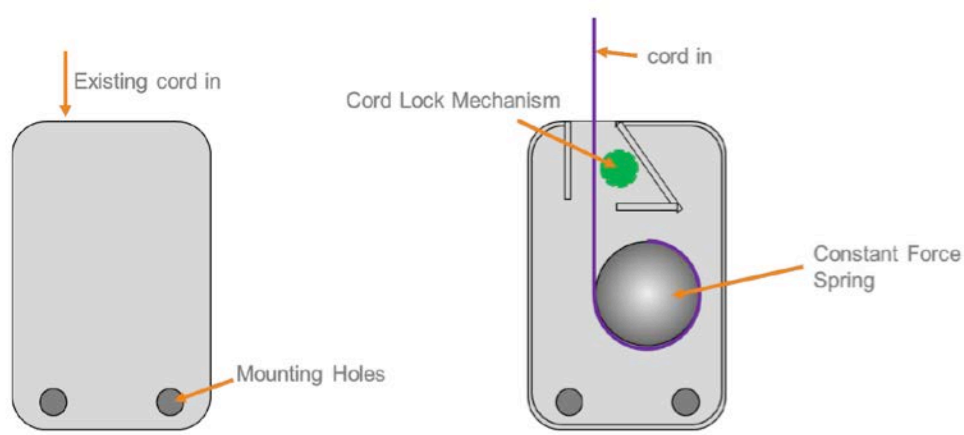

Figure 59. Mechanism 2 Design Mounted Pull Cord Reeling Accessory

The mounted reeling accessory shares much of the same cord lock components with the baseline design. Thus, Mechanism 2 is subject to the same durability concern of the friction mechanism used in the cord lock system. Both the cord lock system and mechanism 2 rely on a knurled locking roller to grip the cord. The greatest concern is potential wearing out of the operating cord due to its repeat contact with the knurled locking roller. The housing of the accessory must also be able to resist high forces and remain rigidly attached to the customer's window frame when consumers operate the product. The connection between the housing "box" and the window frame could loosen over time and stress and fatigue fractures could occur in the housing plastics. Although proper material selection and plastic component design could mitigate these risks, there are several unknown and uncontrollable parameters that may affect the durability of the product such as the end user's window frame material and screw penetration depth of the application site.

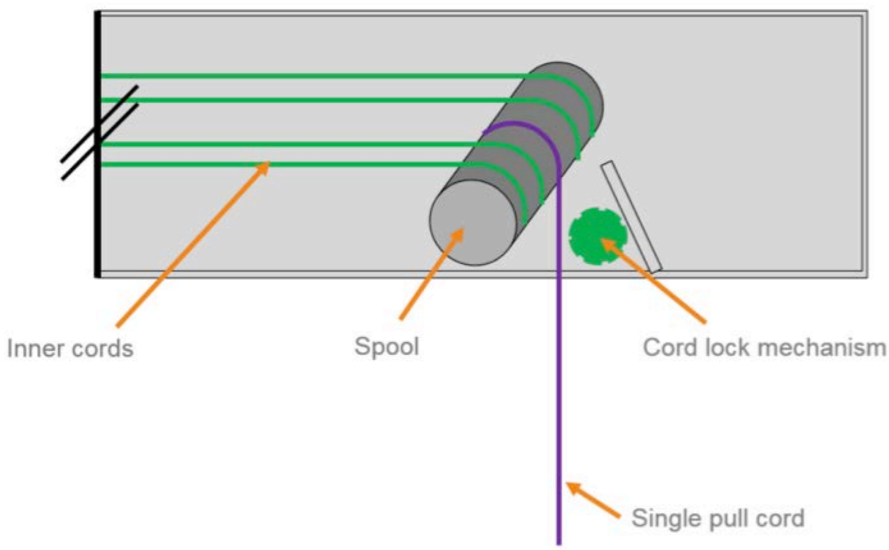

Figure 60. Mechanism 3 Design Integrated Cord Reduction

The integrated cord reduction method utilizes a cord lock friction mechanism similar to the previous baseline Cord Lock (438), meaning the pull cord is subject to wear caused by friction/interaction with the roller element, creating a durability risk. The integrated solution also uses a single rolling spool element inside the head-rail. This spool is subjected to high user loads and the bearing supports of this spool are a potential wear and durability concern. Many low cost head-rails are extruded plastic and offer less rigidity to support the spool as well. Ware and break down of the spool bearing locations could increase the force needed to operate the mechanism or cause a complete mechanism failure.

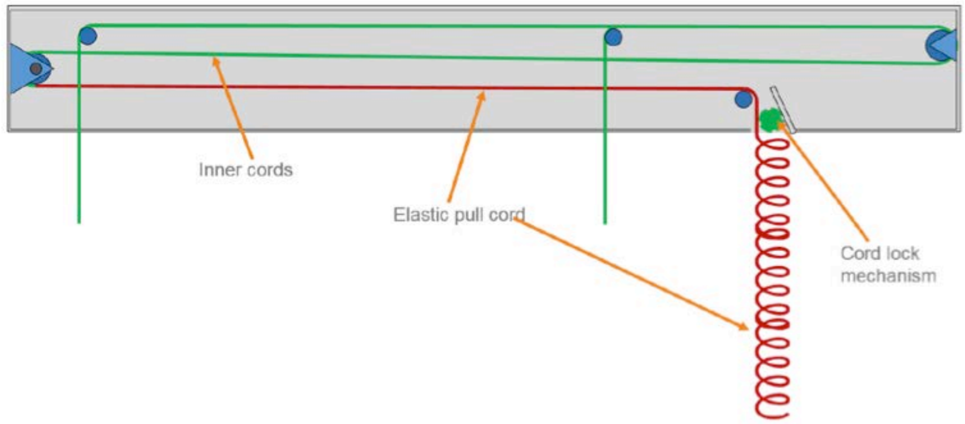

Figure 61. Mechanism 4 Design Elastic Pull Cord

The durability of the elastic pull cord solution shares the same cord lock wear and knurled roller contact concerns as previous designs. The elastic pull cord has a flexible outer sheath to allow the cord to expand in length and diameter. This flexibility further increases the risk of wear and damage when the cord lock is activated. The elastic material will also expand around and potentially into the knurled locking surface, and also increases the risk of damage when the operating cord is pulled taught again. The internal roller and pulley elements are low durability concerns since they are attached to the end caps of the head-rail. The end caps used in higher quality models can be smaller, higher strength injection molded components compared to the relatively low-cost extruded plastic head-rail. These caps also compress against the head-rail in compression, the extruded components strongest loading direction. This is the strongest, stiffest direction to apply load on the mechanism, and thus would be most likely to survive repetitive use. Finally, the connection between the elastic cord and fixed cord is not fully defined in this concept. This connection point is a potential wear and failure point.

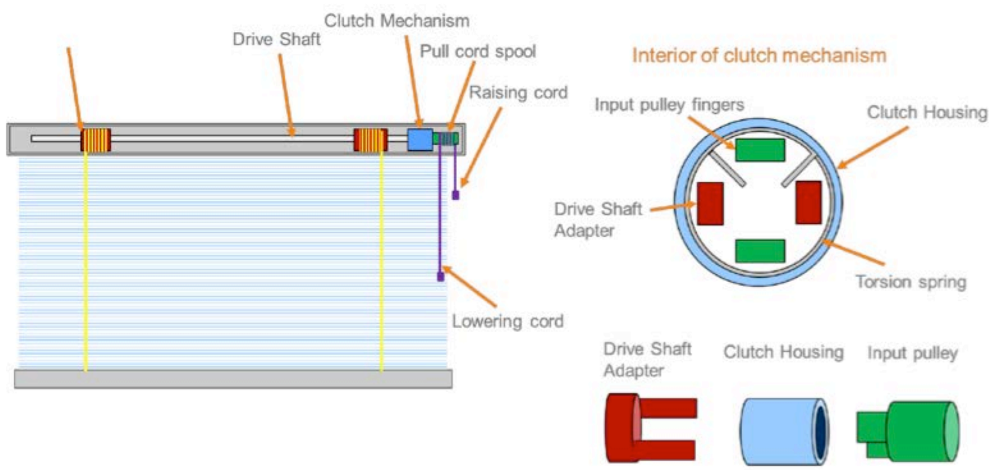

Figure 62. Mechanism 5 Design Simple Wound Cord

The simple winding cord mechanism has a few durability concerns. The highest risk area is the pull cord spool and its attachment to the head-rail assembly because the spool must resist the user force, which is higher than nominal due to the internal gearing. A robust bearing connection is required in the final design. Friction of this rolling element will also increase the user force required and exacerbates the durability risks of the spool attachment. The internal clutch mechanisms and drive shaft supports are low risk durability concerns.

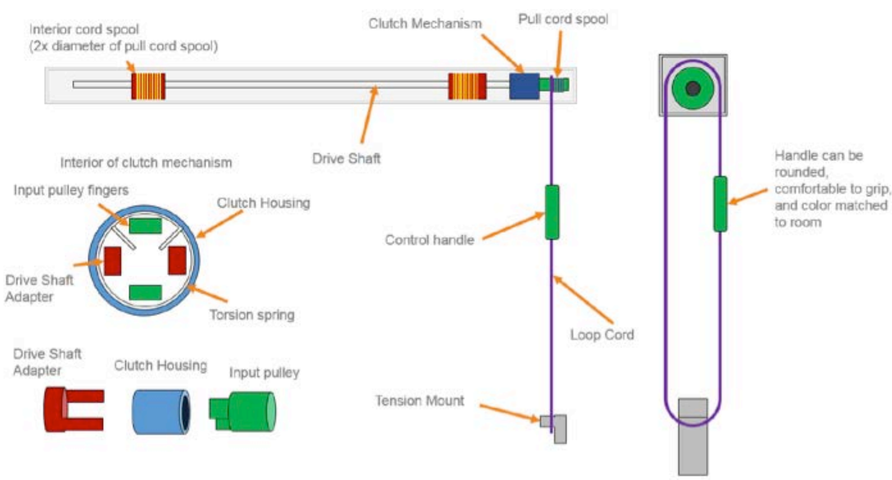

Figure 63. Mechanism 6 Design Fixed Cord Loop With Handle

The fixed cord loop with handle has a few durability risks. Like Mechanism 5 Simple Wound cord, Mechanism 6 shares the same spool mounting and friction concerns. The control handle attachment to the loop cord is another potential wear and failure point, as users are likely to twist or rotate the control handle as the mechanism is raised and lowered. This motion of the handle can weaken the connection points of the handle to pull cord, and over time, the handle can feel loose or potentially slip relative to the pull cord. A secure connection with proper strain relief of the handle to cord could mitigate these risks in the final design.

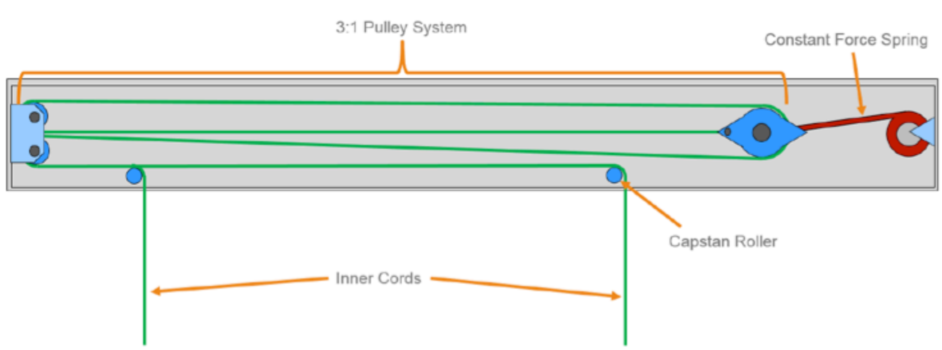

Figure 64. Mechanism 7 Design Pulley Actuated Cordless

The pulleys used in the cordless mechanism have similar durability concerns to existing cordless solutions. These pulleys require guidance and smooth rolling over pivots to provide consistent feel over the life of the product. The proposed mechanism is subject to the same wear and debris impacts on these rolling elements. There are fewer part contact surfaces in the proposed option and thus lower risk of part wear and internal debris generation. Spring wear is a low overall risk. The operating life of the single constant force spring can be greater than the expected life of the window covering. Typical industry standard operating life of the springs can exceed 10,000 or even 50,000 cycles, translating to greater than 13 years if the blind is fully operated 1x per day (365 days, 1 up + 1 down cycle/day, 10,000 cycle life spring). The proposed mechanism, like the baseline cordless product, requires balance in the spring force balance and product mass. The friction locking elements in the proposed mechanism could be susceptible to dirt and debris build-up and subsequent changes in friction values of the cord and spool materials. This can be mitigated with an external locking element, e.g., a cordless system that raises or lowers via button.

3.6 Comparative Analysis of Ease of Use (current vs. implemented changes)

This section compares the ease of use of each mechanism and technology to existing products. The analysis considers three aspects to ease of use: access to controls, interaction method, and interaction familiarity.

An evaluation of access to controls considered whether the proposed mechanisms provide highly visible interaction points that can be accessed by users. Products that have limited access to controls were considered more difficult to use.

The evaluation also considered the interaction method or procedure between the user and the product. The evaluation considers the number and difficulty of steps a user must perform to actuate a given mechanism. Products that require simple or few steps to actuate were considered easier to use than products that required more dexterity or more complex interactions.

The evaluation considered the user's familiarity with certain types of window covering operating systems. Technologies for design concepts that require user interaction similar to that of existing technologies are considered "more familiar." Familiarity with an interaction increases the likelihood of manufacturer's recommended use. If an interaction is less familiar then any learning curve, how easy it is to learn or understand, is considered.

The analysis does not consider the forces required to operate the window covering as part of the criteria. Discussion and analysis of pull force and the window covering mass can be found in section 3.3 (Development of the mechanisms 1 through 7 (Modifications, Applicability, and Limitations of Technology).

3.6.1 Mechanism 1 Ease of Use

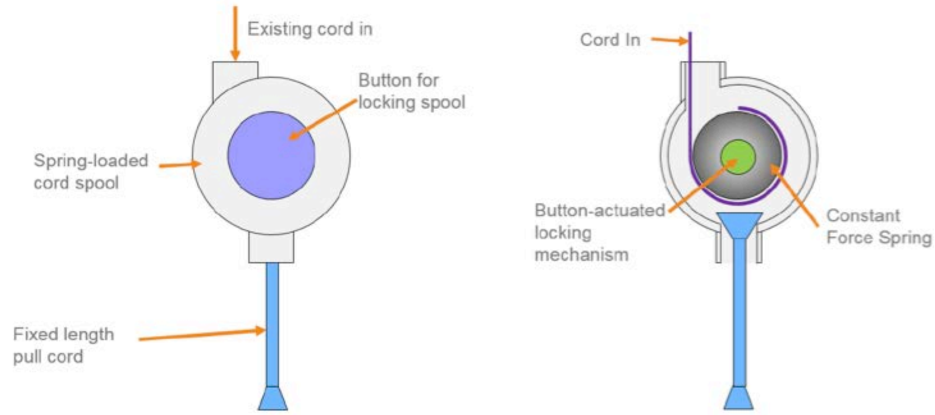

Figure 65. Mechanism 1 Design Pull Cord Reel Accessory

Mechanism 1 has a large central button that would make it as easy to actuate as existing technologies are, if not more so. However, eliminating the pull cord may potentially create a reach issue for shorter users. In addition, tall windows and obstacles such as furniture would further reduce the ease of access. Mechanism 1's interaction for raising and lowering a window covering is identical to existing cord lock systems and requires simple additional manipulation to retract/reel the operating cord. Its similarity to current cord lock and blind winder products is beneficial as users might view it as familiar.

3.6.2 Mechanism 2 Ease of Use

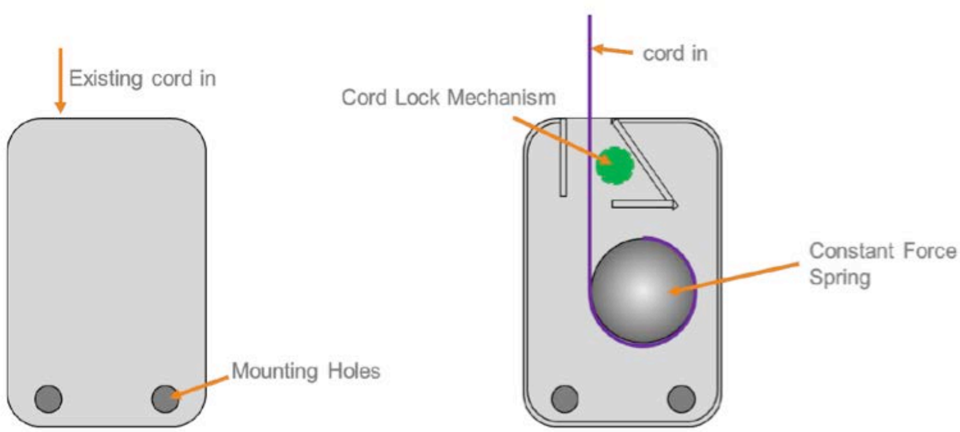

Figure 66. Mechanism 2 Design Pull Mounted Cord Reeling Accessory

Ease of use of this mechanism is similar to existing corded technologies with the potentially added benefit of cord management. The design system prevents operating cords from possible entanglement. While not as accessible as a long cord on a standard cord lock system, this solution allows the user to access the operating cord anywhere between the head-rail and the reeling accessory. This provides access that is comparable to continuous cord lock products. The reeling accessory is permanently mounted to the window frame, keeping the operating cord always within reach of the user. While the required interaction with the operating cord is similar to the cord lock systems, it may feel different when being pulled. Unlike a standard cord lock system where the operating cord dangles and ends in a knot, the operating cord for mechanism 2 is connected to the reeling accessory and not free like in a standard cord lock product. Unlike mechanism 1, a user does not interact with the reeling accessory; only with the operating cord. This enhances the ease of use. Once the user begins to pull the cord, it should feel familiar to a standard cord lock.

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3.6.3 Mechanism 3 Ease of Use

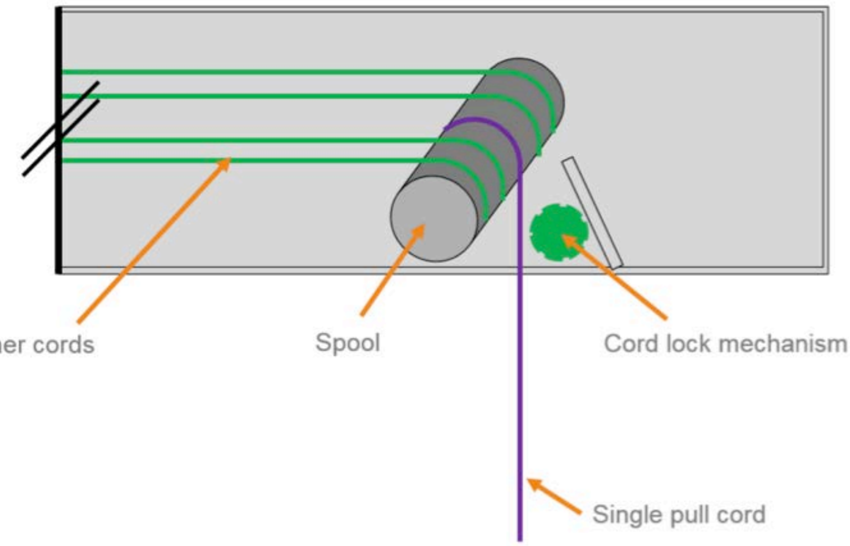

Figure 67. Mechanism 3 Design Integrated Cord Reduction

The ease of use for Mechanism 3 is identical to an existing cord lock system. Mechanism 3 provides the user with the same level of access and identical actuation method as standard cord lock systems. Motiv believes users would likely consider mechanism 3 as familiar. Some users may dislike the proposed pull cord in Mechanism 3 due to aesthetic or ergonomic reasons. However, it would be easy to improve the thickness and texture of the operating cord.

3.6.4 Mechanism 4 Ease of Use

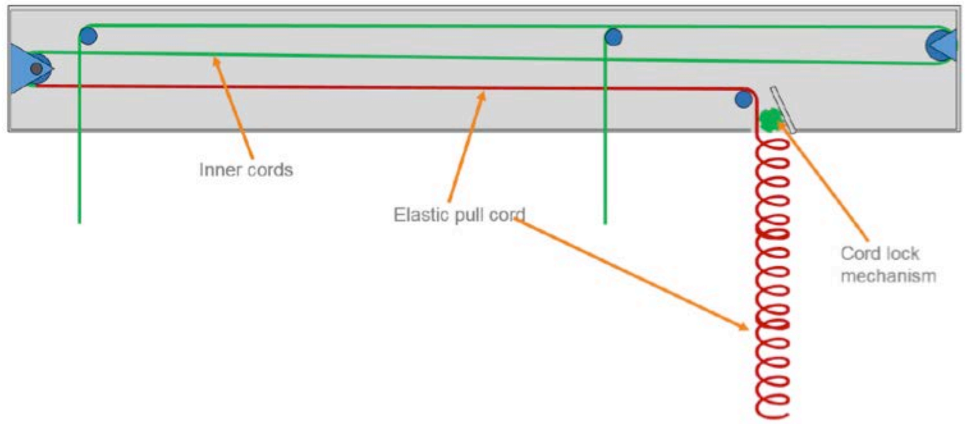

Figure 68. Mechanism 4 Design Elastic Pull Cord

The ease of use of Mechanism 4 is similar to a standard cord lock system. Some users may consider the mechanism familiar. However, the fact that the elastic cord needs to be extended to its full length before the product begins to move makes it inconsistent with the behavior of a standard cord lock. This means the user has to pull a very large amount of cord in order to move the window covering a small amount. Some users may overcome the learning barrier after initial uses of the mechanism while others may not and consider the mechanism difficult to use. Some users may believe the mechanism is slow, sloppy, and not in perfect working order.

3.6.5 Mechanism 5 Ease of Use

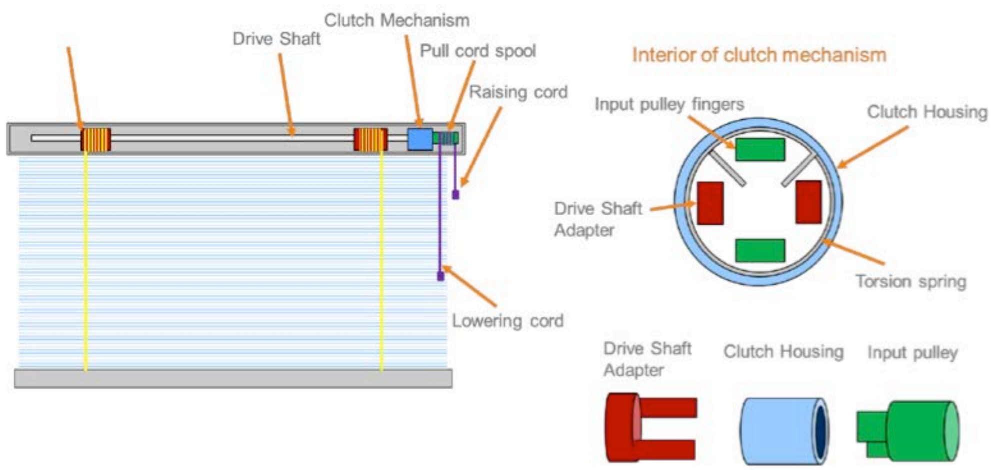

Figure 69. Mechanism 5 Design Simple Wound Cord

Ease of use of mechanism 5 should be similar to existing cord loop products. It replicates the functionality of a continuous loop cord with two single, non-looped, operating cords. However, users may consider the two operating cords less familiar than traditional corded systems and first time users may not know which cord to pull. An experimental pull on one cord should eliminate the learning curve. This is no different than testing the direction on current looped cord mechanisms. Unlike a looped cord, the user no longer has to pull on the loop, reposition their grasp, and pull again to continually raise and lower the window covering.

3.6.6 Mechanism 6 Ease of Use

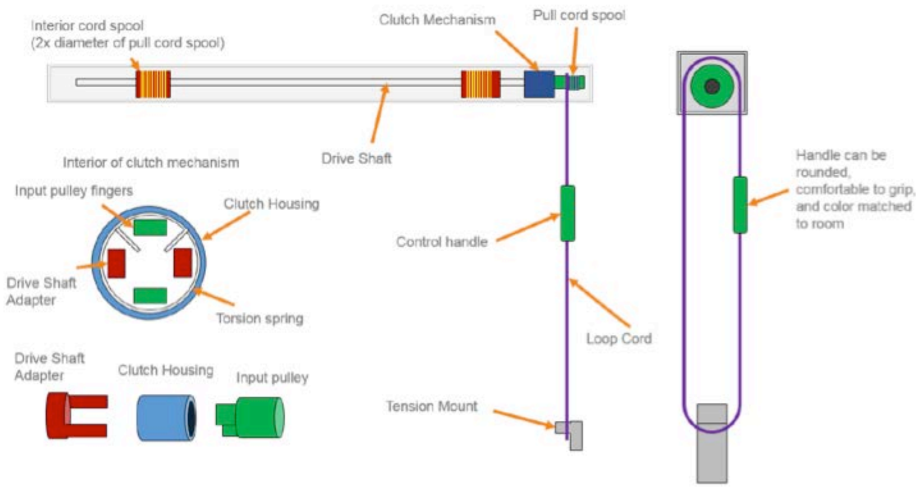

Figure 70. Mechanism 6 Design Fixed Cord Loop with Handle

Mechanism 6 should be easy to use because it replicates the functionality and appearance of a continuous loop system. The appearance provides a visual cue to the consumer on how to operate the product. While this cord loop has many improvements over the standard, it should be very recognizable to users because access to the operating cord is the same as existing corded systems. The handle in mechanism 3 could enhance the tactile feedback when gripping the operating system. The gearing and addition of the handle eliminates the multiple pulls of a standard cord loop mechanism. Because the directionality in operating the cord is intuitive, users are likely to perceive the mechanism as very simple. If the user moves the handle up, then the window covering will raise.

3.6.7 Mechanism 7 Ease of Use

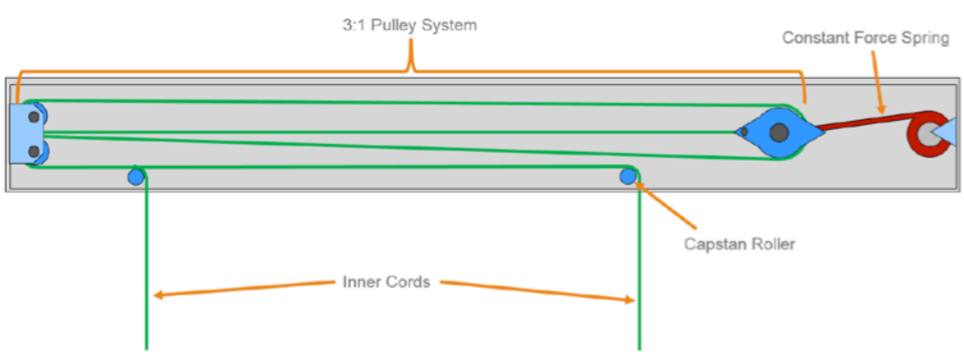

Figure 71 Mechanism 7 Design Pulley Actuated Cordless

The ease of use of Mechanism 7 should be similar to the cordless technologies tested in this project. Tall windows and obstacles, such as furniture, will limit the user’s reach. Users may need to use another solution to operate the system, e.g., the user could add a pull wand to the bottom rail to reduce the negative impact the mechanism design has on reach, although that would have a negative impact on aesthetics. The mechanism is meant to move up and down easily. This mechanism should be identical to current cordless offerings in terms of access and use.

3.7 Comparative Analysis of Aesthetic Appeal (current vs. implemented changes)

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The technologies developed in phase 3 of this project and discussed in 3.3 of this document are conceptual, no products have been manufactured, and these mechanisms have not been reviewed by potential users/consumers. In comparing the aesthetic appeal of these new mechanisms to existing technologies, some conclusions can still be made. The following section discusses each mechanism's aesthetic appeal.

The analysis considered the mechanism's overall look, interaction points, and visual cues. The evaluation considers the aesthetical appeal of the new mechanism(s) to window coverings and existing operating systems. The evaluation also considers whether the mechanism has an interaction point (or feature) that would make it obvious and clear to use to the user. In addition, the evaluation considers how well the actuation mechanism visually communicates its ability to affect the movement of the window covering. Mechanisms with obvious visual cues are rated "high."

3.7.1 Mechanism 1 Analysis

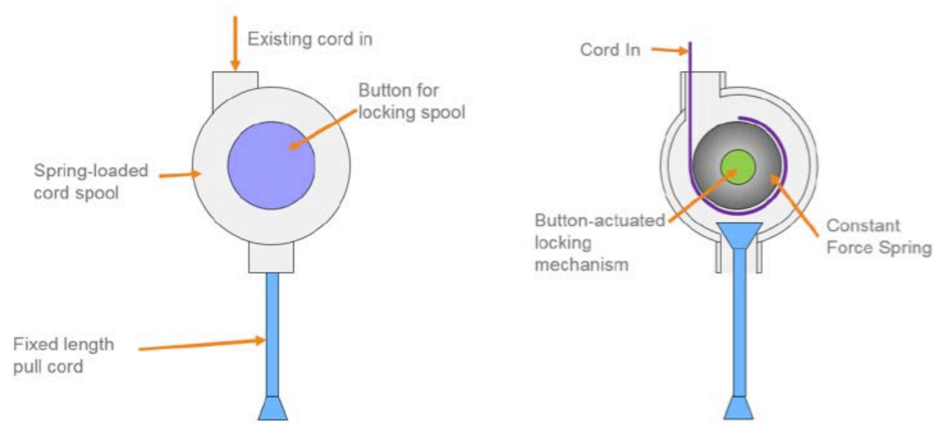

Figure 72 Mechanism 1 Design Pull Cord Reel Accessory

Mechanism 1 has the potential to have simple, clean overall aesthetic. It should be relatively unobtrusive compared to the standard cord lock. Mechanism 1 presents the user with a clear place to grasp and operate the product. With the addition of a fixed pull cord, the mechanism offers a traditional and expected look for a window covering control. A large centralized button to lock the spool helps the device's actuation appear more obvious and simple. This technology could be housed in a variety of forms and colors to match and/or accent the window covering with which it is paired. A more universal design that would be intended to work with many coverings should have a housing that is as minimal and unobtrusive as possible.

Mechanism 1 should have more appeal than the functionally similar BlindWinder. The color and form of said BlindWinder is minimal and functional in nature. Its white color may appeal to users who have white window coverings that match. However, other users could perceive the BlindWinder as unattractive when paired with a contrasting color or natural material window covering. Having multiples of the BlindWinder in a room may further diminish its attractiveness. The form of the Blindwinder does not suggest the product contains handle and users may not understand that the housing serves as an interaction point for a window covering actuation mechanism. Users may be unclear if they should use the Blindwinder as a handle or pull the cord itself then wind up excess cord length with the winder. In contrast the obvious appearance of the pull handle and actuation button on mechanism 1 will provide users with traditional visual cues.

Figure 73 BlindWinder

3.7.2 Mechanism 2 Analysis

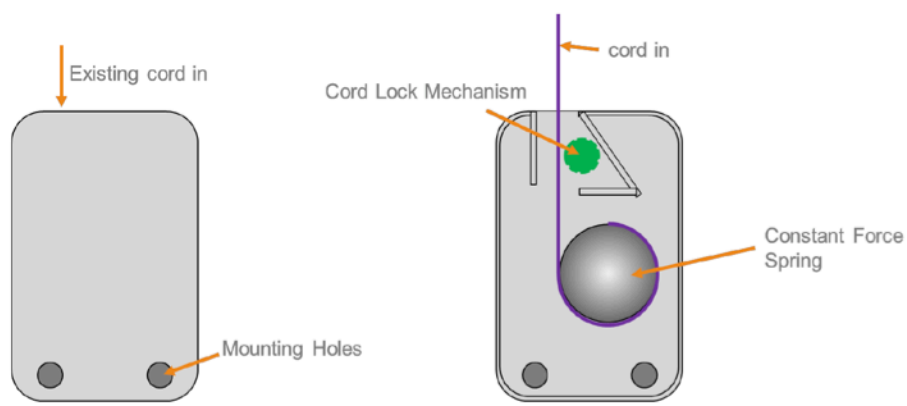

Figure 74 Mechanism 2 Design Pull Mounted Cord Reeling Accessory

The overall look of mechanism 2 is very similar to the Blindwinder, with the slight improvement of being less obtrusive. The technology in mechanism 2 is fixed to a wall or window frame. The housing could be manufactured in a variety of materials and colors to match window coverings and/or surrounding woodwork. Once installed, the reel accessory does not need to be manipulated by the user and, thus, shouldn't be misinterpreted as an interaction point, such as a button or similar feature.

3.7.3 Mechanism 3 Analysis

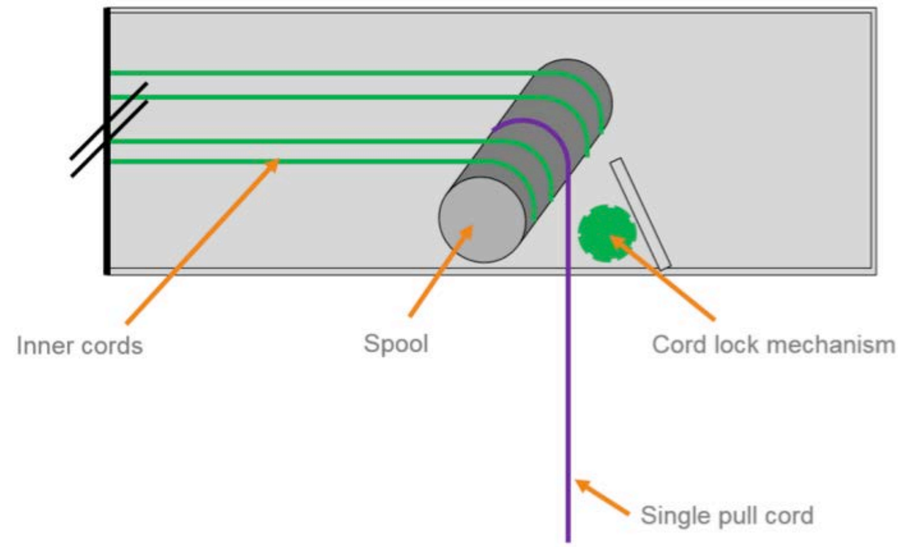

Figure 75 Mechanism 3 Design Integrated Cord Reduction

The appearance of mechanism 3 should be similar to standard cord lock technologies. Motiv believes that a single pull cord makes the mechanism appear more visually simple and clean than other dual pull cords used in a standard cord lock mechanism. However, the aesthetic impact of a single cord is minimal. It can be expected that potential users will find this on par with the aesthetics of current cord lock mechanisms.

3.7.4 Mechanism 4 Analysis

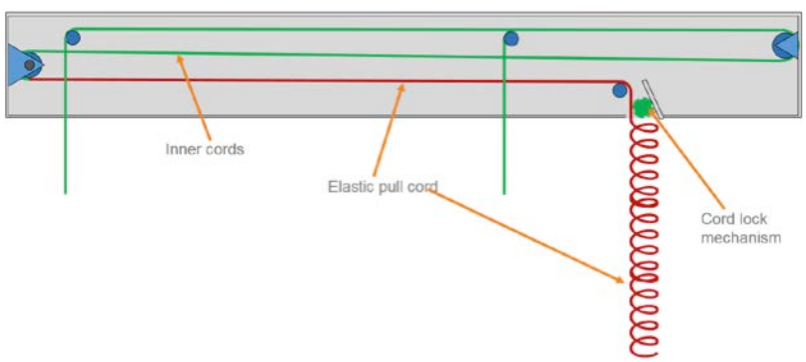

Figure 76 Mechanism 4 Design Elastic Pull Cord

The overall aesthetic appeal for Mechanism 4 depends on the aesthetic appeal of its elastic pull cord. The cord should coil consistently and appear uniform. If the coil retracted unevenly or sags, users may view the mechanism as haphazard and find it aesthetically cheap, old, and fatigued in appearance. Assuming the elastic cord looks clean and collected, the overall appearance would be on par with current cord lock technologies.

3.7.5 Mechanism 5 Analysis

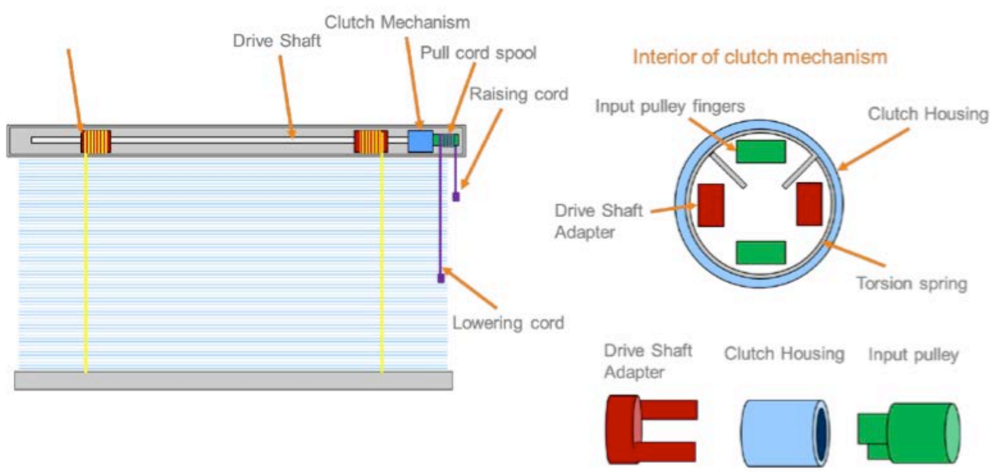

Figure 77 Mechanism 5 Design Simple Wound Cord

The overall appearance of mechanism 5 should be similar to the standard corded systems. However, the main difference between mechanism 5 and the continuous loop system is that the loop system is cut into separate cords. The tassels in mechanism 5 provide visual cues for operation. They could also incorporate additional indicators, such as molded in arrows, to communicate direction further enhancing these cues.

3.7.6 Mechanism 6 Analysis

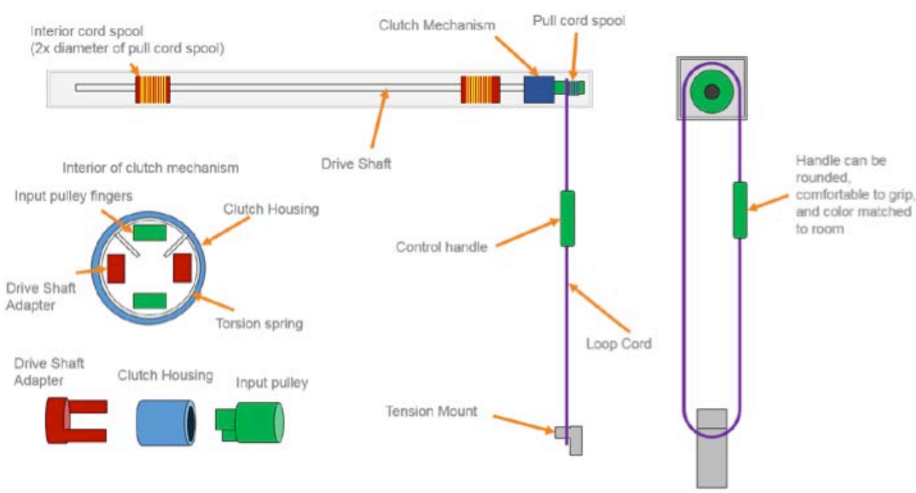

Figure 78 Mechanism 6 Design Fixed Cord Loop with Handle

Mechanism 6’s overall appearance is simple and clean. This mechanism provides a very clean visual cue for actuation; it has a very noticeable handle affixed to the cord loop. Mechanism 6 offers clear indicators: mechanism visually communicates its ability to affect window-covering movement in an easily understood manner.

3.7.7 Mechanism 7 Analysis

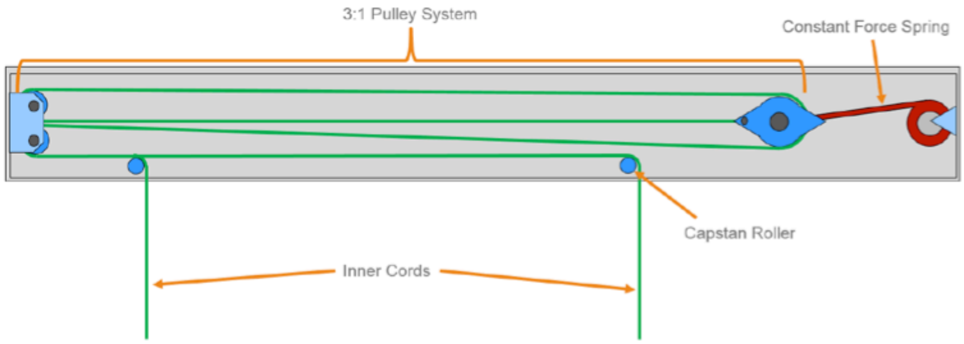

Figure 79 Mechanism 7 Design Pulley Actuated Cordless

The overall aesthetic appeal of mechanism 7 should be high. This mechanism should have an extremely clean appearance like existing cordless solutions. The lack of an additional handle cord or other feature to communicate where to actuate this mechanism actually enhances its interaction point. With no other feature to manipulate, users are left with only the option to raise or lower the covering by pulling on the bottom rail. To further emphasize that the bottom rail is the interaction area, a subtle texture change or handle feature could be added.

3.8 Discussion and Interpretation of Results

It is important to investigate the proposed mechanisms as a balance of safety, feasibility, compatibility, and cost reduction. Some of the redesign ideas with the greatest potential safety improvements also have the high cost impacts. Consumer adoption may suffer if new products are not perceived as being safer, or if their operation is non-intuitive. The cost impacts extend further than the simple costs of goods found through this report's investigation, as manufacturers will be required to re -layout shops, draw new product roadmaps, and develop new resources for managing new products. Intellectual property conflicts may also arise and licensing costs can also increase the cost of these redesigned products. To remove potential cost variations based on overall quality of components used, the lowest cost examples of each technology was compared.

3.8.1 Performance and Feasibility Impacts

All proposed design iterations show basic mechanical feasibility to support a variety of window covering styles. In production, most final designs must be matched to the specific covering to use the appropriate spring values, pull cord lengths, and gear ratios. A single component configuration is not a one-size fits all solution. Mechanisms 3 (Integrated Cord Reduction), mechanism 4 (Elastic Pull Cord), and mechanism 5 (Wound Pull Cord) will require different cord lengths for different width and length coverings. Mechanism 7 (Pulley Actuated Cordless), will also require different springs to accommodate different weights of window coverings.

Aesthetic impacts are significant in this product space and these design iterations attempted to minimize the visual impacts of the proposed designs. Physical mock-ups and hands-on user feedback is recommended to gauge the sensitivity to these solutions.

Additionally, there is conflicting intellectual property for many of these proposed mechanism alternatives which can slow or even prevent their advance.

3.8.2 Compatibility Impacts

All of the redesign products are installed with similar tools and alignment requirements as standard window coverings available in the market today. If a consumer were to purchase these proposed mechanisms, they would already be familiar with their installation as well as use. Mechanism 1 (Pull Cord Reel Accessory) and mechanism 2 (Mounted Cord Reeling Accessory) can be installed as retrofit devices. Consumers would be able to purchase these safety devices and install them to their current window coverings preventing them from having to purchase and install entirely new products. Since the operation of the design alternatives mimics that of mechanisms already in the market, the adoption risks should be low.

3.8.3 Safety Impacts

The proposed mechanism solutions improve user safety compared to actuation methods in existing products. Motiv ranks operating systems that do not have long operating cords or use cordless systems as highest in safety. Products that contain long, dangling operating cords represent lower improvements to safety. Motiv believes (it can be assumed) single operating cord systems would be safer for consumers to use than the multiple pull cords found on existing products, as a single pull cord is less likely to tangle around an object or appendage.

Mechanisms 1, 4, and 7 represent the safest product concepts since the operating cord is capable of fully retracting (Figure 80) and Mechanism 7 does not have operating cords. The single cord solution in mechanism 3 could facilitate additional cord management technologies, e.g. the operating cord could be designed to retract.

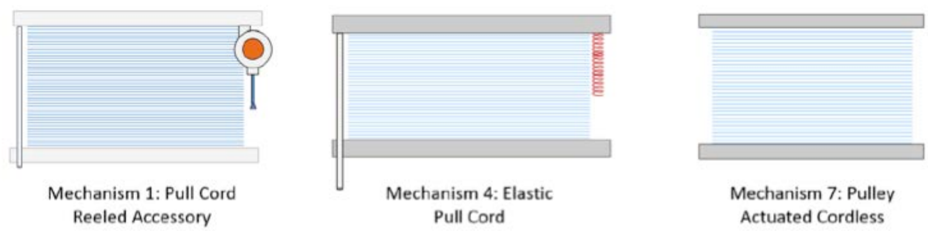

Figure 80 Highest Safety Improvement Solutions

Mechanisms 2 and 6 still involve lengths of tethered operating cords which can be formed into hazardous cord loops at a much higher elevation than the current cord-lock or cord-loop solutions (Figure 81). These solutions represent a small improvement over the current low-hanging cords.

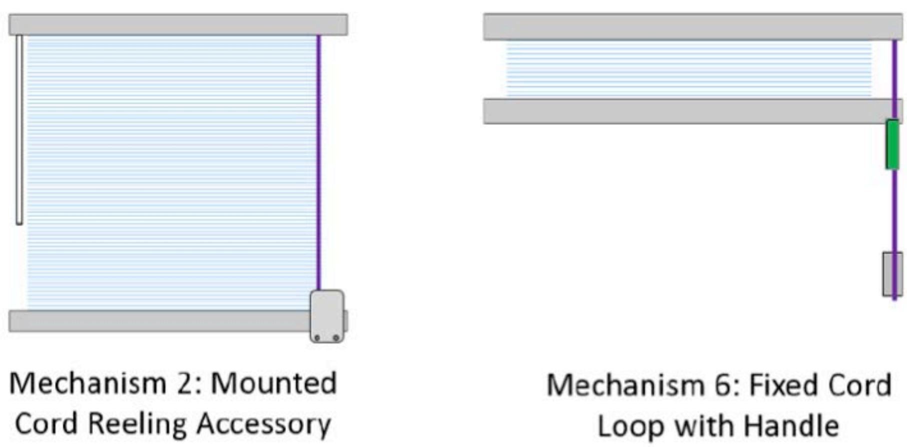

Figure 81. Moderate Safety Improvement Solutions

Mechanisms 3 and 5 represent the least viable safety improvement since these product ideas contain exposed cords (Figure 82). Consumers would need to interact with the operating cords in multiple steps in order to raise or lower the product.

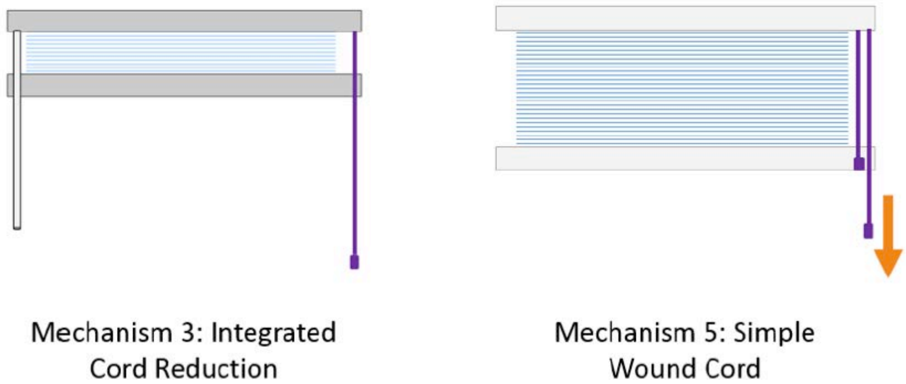

Figure 82 Low Safety Improvement Solutions

3.8.4 Cost Impacts

There may be large margins for these products and the proposed mechanisms targeted modifications to products at the lowest retail price point. In order to bring these new mechanisms to market, manufacturers would have to retool and create new shop workflows, which can also be expensive. Firms can produce the proposed options with existing manufacturing or assembly techniques.

Overall, the design concepts will not significantly lower the potential retail price of the product by introducing new safety features. A few mechanisms show potentially equivalent manufacturing costs (mechanism 3 – Cord Reduction) and mechanism 5 – Simple Wound Cord) but these solutions provide a minimum of increased safety or performance features.

The loop cord with a dedicated user handle (mechanism 6) shows a possible $0.32 or 29% increase in manufacturing cost. This is a large increase in percent manufacturing cost, but a small increase compared to the baseline product retail price of $150 in that product category.

Mechanism 7 (Pulley Actuated Cordless) shows the only potential cost reduction in the proposed solutions. This mechanism represents an estimated $0.22 or 25% reduction in overall manufacturing cost. This cost saving is focused exclusively at lowering the potential retail price of the cordless solutions. It does not provide any increased safety or performance compared to the baseline cordless products on the market.

The pull cord product has the lowest mechanism cost of all products evaluated as well as the lowest retail price. However, the pull cord options (mechanisms 1, 2 and 4) increase the potential retail price of the product relative to existing corded technologies. The solutions represent 9%-27% (or $0.08 to $0.24) increase in the potential manufacturing cost over the baseline product in this category.

Table 9 shows the mechanisms/concept ideas with the lowest cost offering relative to the baseline corded product. The figure shows the cost of the raise/lower portion for each operating system.

Table 9 Lowest Cost Raise and Lower Options by Mechanism Type

Type	Mechanism/Product:	Raise/Lower Mechanism ONLY Estimated COGS	Estimated % Increase in Mechanism COGS
Pull Cord	Lowest Cost Baseline (product 438)	$ 0.359	0%
Pull Cord	Mechanism 1, Pull Cord Reeling Accessory	$ 0.447	24%
Loop Cord	Mechanism 5, Simple Wound Cord	$ 0.555	54%
Cordless	Mechanism 7 - Pulley Actuated Cordless	$ 1.142	218%

The improved safety features reveal the component cost would increase regardless of the operating system. Changes to the pull cord mechanism would result in the price of the baseline components increase by greater than 24%. Converting a pull cord to continuous loop cord system would increase the cost of components by over 50%. Firms may see the cost of producing components triple if the window covering operating system convert to the technology used in mechanism 7.

In the higher-priced window covering products, the cost of additional safety features and components reflect a very small percentage of the overall cost. Similar manufacturing volumes were also assumed for these higher-end products but many of the high-cost solutions are built to order and/or generally lower volume solutions than the commodity pull cord (cord-lock) offerings. The manufacturing volume can have drastic price impacts on the individual components.

3.9 Conclusion

The window coverings industry is a saturated market with extensive research and development and considerable existing intellectual property. All baseline products assume manufacturing process with appropriate high-volume design methods. There is no “low-hanging fruit” to reduce the cost of the baseline products.

Motive designed and developed seven different design mechanisms to address strangulation hazards for window coverings. Motiv analyzed feasibility and cost implications to improve the overall safety performance of the window coverings. The analysis shows that low cost options for increasing safety of the mechanisms are feasible; however, small cost increases can affect the retail price for low priced products.

The pull cord (or cord lock) mechanism represents the most common variety of window coverings and poses the greatest safety risk to consumers. A number of mechanisms developed in this report show promising direction for this target group, namely the pull cord reeling accessory devices (Mechanism 1: Pull Cord Reel Accessory, Mechanism 2: Mounted Cord Reeling Accessory) and the elastic coiled pull cord mechanism (5 Mechanism 4: Elastic Pull Cord). The pull cord reel options can also be used as a retrofit solution to a user’s existing pull cord (cord lock) window coverings. All of these options promote safety while minimizing adoption effort by the consumer. Some of the lower cost solutions may not warrant further exploration as they provide marginal increases in safety.

4 Appendix

Appendix A: Phase 1 Information

Table 1 Product Ranking by Technology

Rank	Identifier	Technology
1	242	Wand / Slider
2	467	Cordless (with tilt wand)
3	271	Cordless (no button)
4	715	Cordless (button)
5	186	Motorized
6	230	Push / Pull Wand (Referred to as Vertical Blinds in Phase 4 report)
7	354	Ratchet with Pull Wand
8	384	Continuous Loop Cord With Tension Device
9	567	Tethered Loop Cord
10	179	Crank
11	317	Twist Wand (Referred to as Cordless Roman Shade)
12	438	Cord Lock

Table 2 Ease Of Use Ranking Averages

Rank	Sample Number	Product Name	Ease Of Use Average
1	242	Wand/Slider	4.47
2	467	Cordless (with tilt wand)	4.27
3	271	Cordless (no button)	4.2
4	715	Cordless (button)	4.1
5	186	Motorized	4.05
6	230	Push/Pull Wand	3.64
7	384	Continuous Loop Cord with Tension Device	3.56
8	354	Ratchet with Pull Wand	3.3
9	438	Cord Lock	3.33
10	179	Crank	2.77
11	317	Twist Wand	2.1
12	567	Tethered Loop Cord	1.95

Table 3 Aesthetic Appearance Rating

Rank	Sample Number	Product Name	Appearance of Controls
1	186	Motorized	4.5
2	715	Cordless (button)	4.1
3	242	Wand/Slider	3.9
4	271	Cordless (no button)	3.9
5	467	Cordless (with tilt wand)	3.6
6	230	Push/Pull Wand	3.5
7	384	Continuous Loop Cord with Tension Device	3.2
8	354	Ratchet with Pull Wand	3.2
9	438	Cord Lock	2.7
10	179	Crank	2.5
11	317	Twist Wand	2.3
12	567	Tethered Loop Cord	2.1

Table 4 Fixed Assumptions For Cost of Modeling

Material & Labor Costs	Density	Required Clamping presure	US	Mexico	China	Malaysia
Burdened Labor Rate			$35	$15	$7	$14
	lbs/in^3	T/in^2	Material Cost, $/lb			
ABS (Cycolac)	0.0379	3			$1.10	
Nylon 6/6	0.0419				$2.20	
Nylon 6/6, 15% GF	0.0448				$2.27	
PC/ABS (Cycoloy)	0.0430	4			$1.65	
Polypropylene	0.0336	2			$0.73	
Polystyrene	0.0226				$0.93	

Machine Type	Reference: Max. Proj. Area (in^2)	Shot Size (in^3)	Machine Rates, $/hr US	Mexico	China	Malaysia
40	10.0	3.61			$25	
60	15.0	6.32			$25	
100	25.0	14.44			$30	
150	37.5	14.44			$30	
250	62.5	19.85			$35	
450	112.5					
500	125.0	90.23			$40	
650	162.5					
850	212.5	270.70			$50	
1200	300.0				$70	

Table 5 Pull Cord and Baseline Cost Comparison

Mechanism (and Product)	Estimated Cost of Mechanism	Estimated Cost of Mechanism Percent Increase	Estimated Retail Price, Including Mark-Up
Baseline (438 Cord Lock)	$0.884	0%	$3.99
Mechanism 1: Reeling Accessory	$0.990	12%	$4.47
Mechanism 2: Mounted Reeling Accessory	$1.126	27%	$5.08
Mechanism 3: Cord Reduction	$0.896	1%	$4.04
Mechanism 4: Elastic Coiled Cord	$0.964	9%	$4.35

Table 6 Cord Lock Mechanism Cost

Mechanism (and Product)	Estimated Cost of Mechanism	Estimated Cost of Mechanism Percent Increase	Estimated Retail Price, Including Mark-Up
Baseline (438 Cord Lock)	$0.884	0%	$3.99
Mechanism 1: Reeling Accessory	$0.990	12%	$4.47
Mechanism 2: Mounted Reeling Accessory	$1.126	27%	$5.08
Mechanism 3: Cord Reduction	$0.896	1%	$4.04
Mechanism 4: Elastic Coiled Cord	$0.964	9%	$4.35

Table 7 Continuous Loop Mechanism Cost

Mechanism/Product	**Estimated Mechanism COGS**	**% Increase in Mechanism COGS**	**Estimated Sale Price ($) includes mark-up**
Baseline (384 Loop Cord)	$1.132	0%	$150.00
Mechanism 5: Simple Wound Cord	$1.097	-3%	$145.36
Mechanism 6: Fixed Loop Cord With Handle	$1.455	29%	$192.80

Table 8 Cordless Raise/Lower Mechanism Cost

Mechanism/Product	**Estimated Mechanism COGS**	**% Increase in Mechanism COGS**	**Estimated Sale Price ($) includes mark-up**	**Estimated Mark-up (Sale $/ Mechanism COGS $)**
Baseline (271 Cordless)	$1.362	0%	$14.97	1099%
Mechanism 7- Pulley Actuated Cordless	$1.142	-25%	$12.55	1099%
Baseline (354 Cordless)	$3.486	240%	$190.00	5450%
Baseline (467 Cordless)	$1.765	46%	$81.90	4640%

Table 9 Lowest Cost Raise and Lower Options by Mechanism Type

Type	Mechanism/Product:	Raise/Lower Mechanism ONLY Estimated COGS	Estimated % Increase in Mechanism COGS
Pull Cord	Lowest Cost Baseline (product 438)	$ 0.359	0%
Pull Cord	Mechanism 1, Pull Cord Reeling Accessory	$ 0.447	24%
Loop Cord	Mechanism 5, Simple Wound Cord	$ 0.555	54%
Cordless	Mechanism 7 - Pulley Actuated Cordless	$ 1.142	218%

Table 10 Product Samples Used in Focus Groups

Technology	Product	Width Inches	Length Inches	Source	Price
Cord Lock	White 1 in. Light Filtering Vinyl Blind Home Depot Brand	23	42	Home Depot (in store only)	$4.47
Loop Cord (Regular)	Luxaflex, 1inch horizontal blind, with loop	24	48	Hunter Douglas	$150.00 Estimate
Loop Cord (Tethered)	Akmida Roller Shade with ChainWand	25	24	CPSC	Unknown
Pull Wand (Ratchet)	2 inch Macro blind w/ UltraGlide, 125 Bright White, w/standard accent hardware color, w/Wand Tilt L, & Wand Pull R	24	48	Barrows	$190.00
Wand / Slider	Holis, Slider 24 inches wide x 48 inches high SILVER	24	48	Holis / Hunter Douglas	$150.00 Estimate
Cordless (with button)	Blinds.com light filtering honeycomb shade moonlight with FREE cordless lift and lock	24	48	Blinds.com	$65.00
Cordless	White Vinyl Light Filtering Cordless Mini-Blinds Allen + Roth	22.5	64	Lowes	$14.97
Cordless (with tilt wand)	Home Depot Bali LightBlocker 1inch Mini Blind	24	48	Home Depot	$81.90
Crank	Luxaflex 1inch Horizontal Blinds with hand crank	24	48	Hunter Douglas	$150.00 Estimate

Motor	Hampton Bay Economy Light Filtering Cellular Shades Motorized	24	48	Home Depot	$119.54
Wand (horizontal push / pull)	Bali Vertical Blinds with one touch control	24	48	Lowes	$52.00
Wand (twist)	Kenney Fabric Roman Shade, Linen	23	64	Walmart	$26.50

Appendix B: Phase 4 Information

Table 11 Consumer Use of Corded Products Prior to Focus Group Work

Frequency (Raising / Lowering)	**Percentage (%)**			
	All 30	**Mothers**	**Grandparents**	**Fathers**
More than once a day	30	30	50	10
Once a day	23	20	30	20
Couple of times a week	30	40	10	50
Once a week	3	-	-	10
Less often than once a week	14	10	10	10
Frequency (Adjusting/Light)				
More than once a day	37	30	50	-
Once a day	23	20	30	30
Couple of times a week	20	50	20	30
Once a week	3	-	-	10
Less often than once a week	17	-	-	30

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Table 12 Perception of Corded Product Performance Prior to Focus Group Work

	Average (5 Point Scale)			
	All 30	Mothers	Grandparents	Fathers
Perceived Safety	2.6	2.5	3.3	2.1
Overall Performance	3.1	2.8	3.6	2.8
Lowering	2.8	2.6	3.6	2.3
Tilting / Adjusting	3.5	3.1	3.9	3.5
Raising	2.9	2.8	3.5	2.4
Control – Feel in Hand	3.0	2.9	3.8	2.2
Appearance of Controls	2.9	2.7	3.3	2.6
Products at Home: Easy to reach, access, and operate?	All 30 (%)	Mothers (%)	Grandparents (%)	Fathers (%)
Yes	73	70	70	80
No*	27	30	30	20
*Reason for saying no: Obstructed by furniture (100%)				

Table 13 Focus Group Results and Analysis

										Would work well in my home? %		
Rank	Sample Number	Product Name	Percieved Safety	Overall Performace	Lowering	Tilting/Adjusting	Raising	Control - Feel in Hand	Appearance of Controls	Yes	Maybe	No
1	242	Wand/Slider	4.3	4.3	4.7	4.1	4.6	4.3	3.9	73	17	10
2	467	Cordless (with tilt wand)	4.4	3.9	4.4	3.9	4.5	3.7	3.6	50	27	23
3	271	Cordless (no button)	4.5	3.8	4.2	N/A	4.2	4	3.9	57	10	33
4	715	Cordless (button)	4.6	3.8	3.9	N/A	4.3	3.5	4.1	40	23	37
5	186	Motorized	4.6	3.7	4.1	N/A	4	4.1	4.5	43	20	37
6	230	Push/Pull Wand	4.1	3.5	3.7	3.6	3.6	3.7	3.5	30	23	47
7	354	Ratchet with Pull Wand	3.1	3.1	3.1	3.7	3.1	3.3	3.2	33	17	50
8	384	Continuous Loop Cord with Tension	3.4	3.3	3.7	3.3	3.7	3.1	3.2	27	27	46
9	567	Tethered Loop Cord	3.8	1.7	1.9	N/A	2	1.7	2.1	0	10	90
10	179	Crank	3.6	2.5	2.5	3.2	2.6	2.5	2.5	13	10	77
11	317	Twist Wand	3.5	2.1	2.3	N/A	1.9	2	2.3	7	10	83
12	438	Cord Lock	1.8	2.6	3.1	3.5	3.3	2.8	2.7	27	13	60

WINDOW COVERING PRODUCT EXAMINATION OUTLINE/GUIDE

For each one of the window treatments on display, please examine each product and assign a rating for each one of the following product performance characteristics. Use the following 5 point rating scale to indicate your degree of satisfaction with each characteristic:

5 = Extremely high, 4 = High, 3 = In the middle, 2 = Low, 1 = Extremely Low

PRODUCT PROPERTY	RATING
1. Lowering the covering; ease and smoothness of operation.	________
2. Tilting/adjusting the angle of the product for light control.	________
3, Raising the covering; ease and smoothness of operation.	________
4. Control mechanism (cord, wand, handle etc.) The feel in the hand, ability to grip and operate the product.	________
5. Appearance of the control mechanisms (cord, wand, handle etc.)	________
6. Safety; prevention of access to controls (cord, wand, handle by small children; elimination of possible risks/hazards.	________
7. Overall product performance and satisfaction	________

"Reason why" for your rating on # 7. Above. Please indicate a word or two of explanation for your rating.

____

____

8. Would this product would work well on the windows in my home.(Check one below).

Yes ______ No _______ Maybe __________

Reason why for your answer on # 8. Above. Please indicate a word or two of explanation for your answer.

____

____

Figure 83. Window Covering Product Examination Guide

Works Referenced

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